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**Revisiting the Green Revolution  
Irrigation and Food Production in Twentieth-Century India.**

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*Revisiting the Green Revolution: Irrigation  
and Food Production in Twentieth-Century  
India.*

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A thesis submitted in fulfilment of the requirements for the degree of  
Doctor of Philosophy

King's College, London  
Department of History

### **Declaration**

This thesis represents my own work. Where the work of others is mentioned, it is duly referenced and acknowledged as such.

KAPIL SUBRAMANIAN

London

31 August 2015

## Abstract

This is a new history of irrigation and food production in twentieth-century India. It seeks to challenge the known story of Green Revolution, to question the role of plant breeding in the history of twentieth century agriculture and to de-centre the big dam from our picture of water and modernity.

This thesis argues that there is no evidence of a breakthrough in Indian food production the 1960s and 1970s where a Green Revolution is typically placed; this was in fact a period of *relatively* slow growth in foodgrain production and yields within an era of high growth that had actually begun around 1950. Wheat, which was a small part of India's food basket was an exception to this general trend of slow growth in the 1960s and 1970s. I argue that High Yielding Varieties of seeds had little to do with this leap in productivity; this was driven by a quick expansion in irrigation facilitated by private tubewells.

Tubewell irrigation was initiated by the colonial state and interwar India had the world's largest tubewell programme. The ability of tubewells to deliver quick results put them on the central government agenda during the Second World War and emphasis on public irrigation (whether from tubewells or dams) increased during the Nehruvian period. The mid-1960s however saw an emphasis on the *private* tubewell, based on a vision of the peasant as a rational profit-maximizing being who was in conflict with public irrigation systems and their equity objectives. The private-profit motive was put at the centre of agricultural policy, and aided by the World Bank, the government mounted a programme of cheap loans to promote private tubewells which quickly became the most important means of irrigation in India.

Putting the tubewell at the heart of my study allows me to re-conceptualise late twentieth-century Indian agriculture. By showing how the World Bank and elite development actors favoured private tubewells, I argue that rising inequality was built into technology choice. This thesis traces the new centrality of the private motive in agricultural policy to Theodore Schultz's theory of the *poor but efficient* peasant and argues that ideas of peasant rationality were also central to the adoption of the HYVs which merely justified appropriation of inoptimal quantities of fertilizer by large farmers to produce super-normal yields even as higher overall production could have resulted from spreading fertilizer thin on tall Indian wheat varieties

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## Introduction

This thesis seeks to challenge the known story of what is called the Green Revolution, to question the role of plant breeding in the history of twentieth-century agriculture and to decentre the big dam from our picture of water and modernity. The Green Revolution is at the centre of late twentieth-century agricultural history in India and the Third World; given the marginality of agriculture in accounts of twentieth-century technology in the rich world, it is central to our picture of twentieth-century agricultural technology more generally.<sup>1</sup> In its simplest form, the story of the Green Revolution goes that many poor countries faced a Malthusian disaster in the late twentieth century; a disaster which was mitigated by a spectacular growth in the production and yield of foodgrains by the adoption of new varieties of seeds developed by plant breeders of the Rockefeller Foundation. The Indian case serves as the usual exemplar. It is implicitly assumed that India's food production was in stasis until the mid-1960s, when the country adopted High Yielding Varieties (HYV) of seeds to achieve a breakthrough in foodgrain production, which enabled it to become self-sufficient in food.<sup>2</sup>

In the following ten or so pages I outline in summary my argument and its relation to existing understanding as a prelude to a detailed review of the literature.

While the social effects of the Green Revolution have long been controversial, the basic narrative as it concerns increased food production and the causes of the increase has not. Nick Cullather's recent work is the first history which questions this classic story, and his critique is largely based on challenging its Malthusian premise; he does this by questioning the nature and the severity of the 1966-67 Bihar famine.<sup>3</sup> This thesis goes further and argues that there is no evidence of a breakthrough in foodgrain production

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<sup>1</sup> The point that there was an agricultural revolution in the rich world in the twentieth century which is scarcely noted in histories of technology has also been noted by David Edgerton, "Creole technologies and global histories: rethinking how things travel in space and time", *Journal of History of Science and Technology* (2007) 1: 86 and David Edgerton, *Shock of the Old: Technology and Global History Since 1900* (2006), pp. 64-65.

<sup>2</sup> This is the general impression, most clearly articulated by Govindan Parayil, "The Green Revolution in India: A case study of technological change." *Technology and Culture* (1992) 33: 737-756.

<sup>3</sup> Nick Cullather, *The Hungry World: America's Cold War Battle against Poverty in Asia* (Cambridge, Ma, 2010), pp. 205-231.

and yields in the 1960s and 1970s; indeed there was a slowdown in the growth rates of both productivity and production of foodgrains as a whole during the period typically identified with the Green Revolution.

Wheat production and yield did indeed see a remarkable growth from the mid-1960s onwards, but as it constituted a relatively minor part of India's production basket, the wheat boom was insufficient to arrest the overall trend of declining growth rates. As I will show, in practice historical studies of the Green Revolution focus on the story of wheat in India (without recognising that it constituted a relatively small part of India's food basket), and tell the tale of the development of dwarf wheat varieties by Norman Borlaug in Mexico and the spectacular impact they had on India, when used with fertilizers.<sup>4</sup> I shall argue that the technology central to the wheat productivity boom was not the dwarf seed varieties (or even just fertilizer) but an expansion in irrigation. This expansion in irrigation took place through the rise of the *private* tubewell which the proximate and intended cause of the growth of wheat production. As some economists have noted, the Green Revolution was really a "tubewell revolution"; noting that a rise in yields has been closely predated by a boom in tubewell ownership in major Green Revolution areas.<sup>5</sup> In other words my contention is that the Indian 'green revolution' of the 1960s and 1970s was confined to wheat, and was not due to the new dwarf varieties. The Green Revolution is not only incorrectly specified; its supposed cause was not the one so influentially suggested by the literature.

Taking a broader view, I argue that there was indeed a general breakthrough in yields and production of foodgrains in India. But that breakthrough began around 1950 rather than in the mid-1960s and growth rates have been significantly and consistently higher in the postcolonial period than in the late colonial period. But the mid-1960s marked the beginning of a decade and a half of relative slowdown in the growth of production and yields of foodgrains; this was followed by a growth spurt in the 1980s, though the 1950s continued to be the decade which saw the best growth performance in twentieth-century India. This has been obscured by the repeated uncritical acceptance of the Green

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<sup>4</sup> John Perkins, *Geopolitics and the Green Revolution: Wheat Genes and the Cold War* (New York, 1997) is the best example. Also see Cullather, *Hungry World*.

<sup>5</sup> See for example Robert Repetto, *The "second India" revisited: Population, poverty and environmental stress over two decades* (Washington, DC, 1994), p. 35.

Revolution promoters in portraying this period as one of stagnation, in order to grossly inflate the *relative* performance of the period they wish to emphasise.

My argument is that irrigation was the most significant technical factor in productivity change throughout the late twentieth century; its significance for wheat in particular increased in the period after the mid-1960s. In the case of rice too, the transformation of irrigation systems was the most significant factor in productivity enhancement but the challenges posed by diverse economic and agro-climatic issues to effective water management in rice cultivation made the transformation of rice irrigation a slow process after the mid-1960s compared to the quick transformation and expansion afforded by private tubewells in the wheat-growing regions of northwestern India. Fertilizer was relatively insignificant to wheat production before the mid-1960s and its importance did indeed rise rapidly through time though not quite in the form of a spectacular breakthrough as is assumed. As for the dwarf wheat varieties, their role was neutral (if not negative) in the late 1960s and early 1970s, the period which forms the focus of Green Revolution studies. They did perhaps indeed become significant in a later period as fertilizer use gradually rose to a point of declining returns with tall varieties. New varieties however played a significant role in the post 1980 transformation of rice production as their short duration photo insensitive qualities enabled the extension of rice cultivation to non-traditional regions and seasons more amenable to higher yields through better water management with tubewells.

An understanding of the causes of this temporally and spatially uneven long-term growth calls for a new history of agriculture during the entire period. This thesis is an attempt at the beginnings of such a history with a focus on irrigation, an input which both historical actors and contemporary experts (though not most historians) agree is the most crucial one in the Indian context.

The story of irrigation in twentieth-century India has not been told. The historiography has largely confined itself to the colonial period and focusses on large-scale canal irrigation systems, and the scant work on water in postcolonial India has focussed on Nehru's dams; indeed the big dam is central to our understanding of postcolonial Indian modernity. But despite the centrality of canals, big dams and other centralizing technologies in our picture of water and modernity, the larger story of twentieth-century irrigation has been a move towards small-scale irrigation systems based on groundwater.

India leads the world in the volume of groundwater extracted annually and this accounts for over two-thirds of Indian irrigation today. The most important means of groundwater irrigation in India is the tubewell; India, indeed colonial India, was a pioneer in tubewell irrigation.

The bulk of this thesis is a first history of irrigation in twentieth-century India which puts the tubewell at its centre. Far from neglecting groundwater irrigation as the literature portrays, I will show that the interwar colonial Indian state did much to promote it and was the global pioneer in the large-scale use of tubewells. This emphasis continued in Nehruvian India where public tubewells were an integral part of investment in irrigation and I will go on to show that there was a massive rise in tubewell irrigation in the 1960s.

While the value of irrigation was scarcely ever contested, three conflicts shaped irrigation development in important ways: between public and private ownership, between large and small-scale systems and between agricultural and industrial investment. These conflicts came to a head at two different points; the wartime food crisis and the economic crisis of the mid-1960s. Both periods saw an emphasis on small-scale groundwater irrigation rather than on large-scale surface irrigation development as the key to quick results. The wartime crisis put the *public* tubewell on the central government's agenda and the emphasis on public irrigation continued through the Nehruvian era.

The crisis of the mid-1960s saw a shift in emphasis from large, long-gestation dam projects to small, quick-maturing tubewell schemes, and a shift in central government priorities from the industrial to the agricultural. But far more significant was a shift in emphasis from *public* irrigation systems to *private* tubewells. The mid-1960s saw an explicit prioritization of the privately-owned tubewell, based on a model of the peasant as an efficient, rational being whose profit-maximizing objectives were in conflict with the social equity objectives of public irrigation systems. The World Bank was the chief enunciator of this argument, which found ready ears amongst Indian politicians and administrators who were seeking to put the private profit motive at the centre of agricultural development efforts. Aided by the Bank, they mounted a programme of cheap loans and subsidies to promote private tubewells which quickly became the single most important mode of irrigation in India, with a spectacular impact on wheat production.

Putting the tubewell at the heart of such an agricultural history allows us to reconceptualise the agricultural policy in a fresh manner. An emphasis on public irrigation

systems, whether tubewells or the big dams characterized the Nehruvian era. By showing clearly how elite development actors led by the World Bank emphasized the private profit motive and thus put private, rather than public tubewells at the heart of the new agricultural strategy in the mid-1960s and thus precipitated a private tubewell boom, I argue that this was an important episode in the long history of state-promoted market-oriented development in Indian agriculture. I explore the intellectual backdrop of these ideas and argue that their genesis lay in economist Theodore Schultz's Nobel Prize winning theory of the "poor but rational peasant". Focus on the promotion of an indivisible input such as the private tubewell rather than on the ostensibly scale neutral inputs such as new seeds and fertilizers highlights the fact that rising inequality was not a side effect of policies but consciously built into technology choice.

Similarly, I shall also demonstrate how the choice of the dwarf wheat varieties was motivated not by the need for higher overall production but to ensure supernormal yields for a small number of entrepreneurial cultivators; tall Indian varieties and more equitable fertilizer distribution would have resulted in higher production with the benefits better shared and with more efficient use of scarce inputs such as land and fertilizer. I thus challenge the central triumphalist success story of plant breeding – that of a Green Revolution caused by new varieties, which is still central to the rhetoric around biotechnology today. As a more general aim, this thesis seeks to challenge the continued innovation-centredness of our understanding of technology and economic development by highlighting the central and leading role played by one of the oldest agricultural techniques (irrigation) in what is assumed to be an innovation-driven production boom. It also challenges the production-centred narrative on Indian food self-sufficiency by arguing that an equally important role was played by logistical changes such as improved procurement, building up of a buffer stock to deal with production shortfalls and state intervention in the grain markets.

The history of late twentieth century Indian agriculture has hitherto largely focussed on one kind of expert (the plant breeder) and non-governmental institution (the Rockefeller Foundation which funded plant breeding research). This thesis also seeks to expand the focus of historical study to new kinds of experts and institutions. Besides the irrigation engineer, this thesis strongly emphasizes the role of economists as key experts grappling with the problems of agricultural development. In addition to emphasizing the role of social scientists as historical actors, this thesis engages substantially with their theory,

rhetoric and the application of their ideas, as well as their studies of the impact of technical change rather than merely quoting them as fact as is too often the case. It also emphasizes the astonishingly neglected role of the World Bank in guiding and financing agricultural development in India. In doing so, it emphasizes that agricultural change was as much about finance and economic policy as it was about technical change.

This thesis also contributes to the historiography of technology in which scale is an important theme; with the implicit suggestion (made explicit in the work of James Scott<sup>6</sup>) is that that states prefer centralization and gargantuan scale and this has something to do with the negative impact of economic development. This thesis shows that small-scale technologies such as tubewells and a vision that placed the individual at its heart could also be central to “seeing like a state”<sup>7</sup> and lead to a diverse set of consequences that while not necessarily negative, were far from socially and environmentally optimal.

Further, this thesis illustrates just how central the argument that existing systems are at some kind of technological or ecological limit is to the promotion of new technologies. Thus it was argued dams and tubewells were needed as (then) conventional surface irrigation development had reached its limits, private tubewells were needed as public irrigation systems could not serve the needs of modern agriculture, dwarf plant varieties were needed as improved tall varieties had attained their full potential and chemical fertilizers were needed as the use of organic manures had reached its full potential. This thesis argues that such arguments were usually erroneous and were made to push for far-reaching social and economic change that had little to do with technology; indeed technological change served to deflect attention from far more controversial policy change.

Finally, this thesis makes a contribution to the history of science, technology and development in India. Existing work on the twentieth century privileges the rhetorical and ideological issues with a consequent neglect of the material aspects of this history. This thesis argues that a study of the material is equally important. It also seeks to provide a corrective to the neglect of the role of the state in the growing body of work on small machines or “everyday technology” of which the tubewell is a prime example.

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<sup>6</sup> James C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed* (New Haven, Ct., 1998).

<sup>7</sup> To borrow from the title of Scott, *Seeing Like a State*.

Cutting across the colonial-postcolonial divide, I argue that there was significant continuity between the two; rhetoric mattered little and for the most part, the postcolonial state merely scaled up British efforts. The standard position, as exemplified by the scholarly work on the Green Revolution, is that postwar “development” was a project with origins in America and rooted in Cold War imperatives; this thesis argues that while American foundations and multilateral institutions such as the World Bank played a significant role, a fuller picture may yet be obtained by concentrating not just on foreign institutions but local ones as well. Indeed as I will show, *longue durée* economic histories of India which appear not to have been read by historians of postwar development pre-empted my arguments about the Green Revolution.

In the next few sections, I shall further develop my critique of the existing historiography of the Green Revolution, irrigation in India, science and technology in India as well as Indian history more generally, and lay out my arguments in relation to the existing literature.

### **Agricultural History: A Green Revolution?**

Despite the seeming coherence suggested by the term, the Green Revolution has many meanings in the historiography. At the global scale, it has been taken to mean the increase in the production and land productivity of foodgrain cultivation in poor countries after the Second World War. But as Jon Harwood has pointed out, this global revolution is merely the agglomeration of several regional and national revolutions that took place at differing times across the developing world in the postwar period.<sup>8</sup> He has used the term to refer to a central European “Green Revolution” during the late nineteenth and early twentieth century.<sup>9</sup>

The term itself was only coined in 1968 by a USAID administrator to describe a potential agricultural breakthrough in South Asia, the Philippines and Turkey to contrast it with the Red Revolution promises by Soviet Russia (and Maoist China) and the Shah’s White Revolution in Iran.<sup>10</sup> But it has been applied to a wide range of national, regional and

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<sup>8</sup> Jonathan Harwood, *Europe's Green Revolution and Others Since: The Rise and Fall of Peasant-friendly Plant Breeding* (London, 2012), p. 115.

<sup>9</sup> Harwood, *Europe's Green Revolution*.

<sup>10</sup> William Gaud’s address to the Society for International Development on March 8<sup>th</sup> 1968 at Washington, DC. Accessed online at <http://www.agbioworld.org/biotech-info/topics/borlaug/borlaug-green.html> on 10th August 2015.

global contexts. Thus the first such revolution, which became exemplar for all others ostensibly took place in Mexico as a result of the work of the Rockefeller Foundation between the 1940s and early 1960s, with the Philippines, India and Pakistan following in the 1960s and early 1970s. For at least 30 years, donors (the latest being the Gates Foundation) have been speaking of a Green Revolution in Africa. In India there are calls for a second Green Revolution (to increase yields in the original Green Revolution state of Punjab where they have apparently been stagnating since the 1990s),<sup>11</sup> a doubly Green Revolution (that is productive *and* environmentally sustainable)<sup>12</sup> as well as an official government programme called “Bringing the Green Revolution to Eastern India” (BGREI) to repeat the Punjab experience in areas still deemed backward.<sup>13</sup>

In the Indian case the revolutionary transformation called the Green Revolution is always placed in the late 1960s and 1970s. As the Indian case serves as the exemplar, the global Green Revolution has typically been periodized during the 1960s and 1970s. The historiography of late twentieth century Indian agriculture has thus focussed exclusively on the events of the 1960s which is deemed to have led to a Green Revolution; a boom in yields which is ascribed to the HYVs.

While social scientists have produced enough scholarly analyses of the Green Revolution “to fill a medium sized public library”<sup>14</sup>, historical treatments are few and far in between. Three key works all pertain substantially to the Indian case; in chronological order, these are the works of Parayil (published in 1992), Perkins (published in 1997) and Cullather (published in 2010).<sup>15</sup> Parayil provides the best specialist exposition of the common understanding of the Indian case, defining the Green Revolution as an “increase in cereal productivity experienced in some Third-World countries as a result of the change in

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<sup>11</sup> Anon., “Swaminathan calls for second green revolution”, *Rediff News* 2nd December 2005. Accessed online at <http://www.rediff.com/news/2005/dec/02swami.htm> on 10th August 2015.

<sup>12</sup> Mae-Wan Ho, “Beware the New “Doubly Green Revolution”, Institute of Science in Society website, accessed online at <http://www.i-sis.org.uk/doublygreenrevolution.php> on 10th August 2015.

<sup>13</sup> Anon., “India becomes world’s leading rice exporter: CARE Ratings”, *India Infoline*, Accessed online at [http://www.indiainfoline.com/article/print/news-top-story/india-becomes-worlds-leading-rice-exporter-care-ratings-114020501004\\_1.html](http://www.indiainfoline.com/article/print/news-top-story/india-becomes-worlds-leading-rice-exporter-care-ratings-114020501004_1.html) on 10th August 2015.

<sup>14</sup> As put by Cullather, *Hungry World*, p. 230.

<sup>15</sup> Parayil, “The Green Revolution in India”, pp. 737-756, Cullather, *Hungry World* and Perkins, *Geopolitics and the Green Revolution*.



agricultural technology during the 1960s and 1970s”; this made India self-sufficient in food production.<sup>16</sup> By his account, a stasis in the growth of food production led to a near famine situation in 1965 due to a neglect of agriculture by the late colonial state and Nehruvian India. The “only way” to self-sufficiency was to “introduce modern technology that would augment cereal production with land as the fixed variable”; in other words to increase yields.<sup>17</sup> This happened through the introduction of the new HYVs of wheat and rice from Mexico and the Philippines respectively, and led to a remarkable growth in yields and production. Simple as Parayil’s overall schema is, he does attempt to posit a longer history of the Green Revolution, dividing it in three phases. The first (1952-65) saw the development of a new agricultural research system. The second (1962-67) saw the reform of the agricultural bureaucracy while the third (1965-75) saw the adoption of the HYVs. Placing a premium on scientific research, he sees the most important step as the setting up of the agricultural research system, though the new varieties were not developed in India. This was so as it enabled a programme of national demonstration to popularize the new seeds.<sup>18</sup> Parayil’s is an unabashed tale of the triumph of science; one of a “relatively successful technology transfer” and “diffusion of knowledge”.<sup>19</sup> The Green Revolution in India thus was essentially the spread of the pre-war plant-breeding-led agricultural revolution in Europe and the United States to the Third World after some unfortunate decades, and this spread took place through the particular HYVs of wheat and rice developed later.<sup>20</sup> The domestic and international political-economic context is absent from this early work. Biologist-historian John Perkins’ history of wheat breeding goes far in correcting this lacuna, though the focus is still on plant breeding. Perkins argues that concerns of national security and foreign-exchange management were central to government commitment to wheat breeding in India, Mexico, Britain and the United States. For the Americans, foreign aid supporting agricultural improvement was tied to strategic cold war aims. Hungry stomachs made for communist insurrection; the so-called Population-National Security Theory. Two portions of the book concentrate on India: a chapter covering the major developments in India’s foodgrain and agricultural research policy, and a long section in a chapter on

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<sup>16</sup> Parayil, “The Green Revolution in India”, p. 737.

<sup>17</sup> Parayil, “The Green Revolution in India”, p. 741.

<sup>18</sup> Parayil, “The Green Revolution in India”, pp. 737-746.

<sup>19</sup> Parayil, “The Green Revolution in India”, p. 737.

<sup>20</sup> Parayil, “The Green Revolution in India”, pp. 741-44.

science and the Green Revolution. Perkins' overarching tale differs little from Parayil's, except in adding detail to the scientific history of the development and trials of the dwarf wheat varieties, and Indo-American diplomatic wrangles over food aid and agricultural development; particularly during the mid-1960s. The key players in his schema are plant scientists and the politicians who supported them.<sup>21</sup>

Thus both these works essentially tell the story of how India solved its food problem by adopting the "miracle seeds". In doing so, they repeat a refined version of the story told by the proponents of the new technology and early eulogists of the Green Revolution which included American and Indian scientists, politicians and agencies such as the Rockefeller Foundation.

Nick Cullather's recent book makes a departure from these works in taking a critical approach, and is perhaps the best account of the Green Revolution thus far. He recasts the spectacle of the adoption of dwarf wheat varieties in India as merely the final episode in two decades of American efforts at remaking the Asian countryside; his is a history of American-aided rural development rather than plant breeding alone. *The Hungry World* is an ambitious work exploring the meaning, means and impact of development through time and space in the mid-20<sup>th</sup> century. Beginning with the measurement of human caloric needs at the turn of the century and new developments in population theory in the interwar years, Cullather argues that awareness the world food problem as perceived in the 1960s had less to do with Malthus than with the twentieth-century methods of coding the world by numbers. Placing the genesis of the development project in the Depression-New Deal era, he goes on to study the Rockefeller Foundation's Mexican Agricultural Program. This, he argues, was recast with selectively remembered features as a model for economic development after the war; it was "an answer in search of a riddle" as other models were in play in the late 1940s and 1950s.<sup>22</sup> Subsequent chapters explore the history of these models such as community development in India, land reform elsewhere in Asia and Tennessee Valley Authority-style dam building in Afghanistan.<sup>23</sup>

The second half of the book deals substantially with the events leading up to the Green Revolution as generally understood. Exploring debates within American academia and

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<sup>21</sup> Perkins, *Geopolitics and the Green Revolution*.

<sup>22</sup> Cullather, *Hungry World*, p. 71.

<sup>23</sup> Cullather, *Hungry World*, pp. 108-133.

administration over modernization, over food aid to India and over the respective roles of agriculture and industry in economic development, he sees the late 1950s as a pivotal moment when a couple of influential reports restored the centrality of the population-food problem. He moves on to the development of the “miracle rice” IR 8 in the Philippines in the 1960s, stressing its importance in furnishing a visual representation of rural development. He next explores how agriculture, and wheat in particular, became the centre of Indian development efforts in the mid-1960s. This is followed by a study of the contrasting American and Indian perceptions of the Bihar famine. The last of the historical chapters begins with the story of the miracle harvest of 1968 and goes on to explore the socio-political impact of the Green Revolution in various countries.<sup>24</sup>

Cullather’s overall argument is that “development” emerged as a central concern of American diplomacy during the cold war. America was influenced by a variety of competing ideas in its confrontation with the continent of peasants, and advisers were never able to settle on a single consensual model of rural development; theory and praxis were driven by a quest for narratives to frame problems. There was a constant quest for spectacles to dramatize the fruits of modernity, and the building of transferrable models of development was central to this American project. Throughout this period, technology was used as a way to avoid historical responsibility and democratic choice. To Cullather then, the Green Revolution was the culmination of these models, a term which “lent coherence to three decades of conflict, innovation, failure, and success”. Intended as a new model rather than as retrospective judgment, the term nevertheless gave a rise to a legend; “a heroic parable of population, food and science solidified into history”.<sup>25</sup>

What is notable is Cullather’s challenge to this narrative. He suggests for example that the self-sufficiency in rice achieved by the Philippines was a case of outright fraud orchestrated by Ferdinand Marcos. Central to his challenging of the myth in the Indian case is his questioning of the severity and nature of the infamous 1966 Bihar famine through his exploration of how the meaning of famine was contested between the provincial, national and American governments in a chapter that ends with an impressive paragraph,

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<sup>24</sup> Cullather, *Hungry World*, pp. 134-262.

<sup>25</sup> Cullather, *Hungry World*, p. 262.

In the 1970s, social scientists and official commissions produced... a mixed verdict on what they called HYVs... [But] a more consequential narrative took root in the press and public memory. The green revolution legend, embellished after 1970 owes much to [President Lyndon] Johnson's imagineering. In this version, the late 1960s witnessed a historic turnaround in Asia's food supply... This simpler and more satisfying account rests on a claim- Johnson's claim- that India actually had a close brush with its Malthusian limit in 1966. It has become the basis for a growing consensus that India's experience should be repeated.<sup>26</sup>

In addition to questioning India's brush with its Malthusian limits, there are other passing hints in *The Hungry World* which challenge the classic narrative. Thus Cullather suggests that Indians were eating better than ever before in the late 1950s; supply was indeed unable to keep up with demand, but the latter was fuelled by rising incomes and evolving consumer preferences rather than by population growth. Far from being in decline, Indian agriculture was actually experiencing something of an export boom; albeit in cash crops such as jute rather than food.<sup>27</sup> As for the seeds he questions their importance by quoting William Gaud (the USAID administrator who coined the term Green Revolution) who said that the new seeds were merely an inducement to get countries to devote more resources to agriculture.<sup>28</sup>

Parayil and Perkins have assumed that the late 1960s and 1970s saw a boom in foodgrain production and have thus focussed on the political-scientific story of how that boom came to be. Cullather, with his interest in the intellectual-diplomatic history of development has based his critique on challenging the Malthusian premise of the Green Revolution legend, seeking to demonstrate how a model based on that shaky premise is being extended today as a development solution today in Africa. While none of these works closely examine India's foodgrain production statistics, they do make strong though vague claims about production growth and the attainment of self-sufficiency. Parayil makes the claim for self-sufficiency in a fairly straightforward manner, though he says yields rose steadily from 1965 till 1975 followed by plateauing and subsequent revival in the late 1980s.<sup>29</sup> Perkins writes that the Green Revolution in rice and wheat "did not end the question of agriculture

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<sup>26</sup> Cullather, *Hungry World*, pp. 230-231.

<sup>27</sup> Cullather, *Hungry World*, pp. 180-183.

<sup>28</sup> Cullather, *Hungry World*, p. 230.

<sup>29</sup> Parayil, "The Green Revolution in India", p. 746.

and food production in India but shifted it onto an entirely renewed plain in which self-sufficiency was a realistic goal.”<sup>30</sup> Cullather makes no specific claim in this regard, though he indicates that he is in assent with the claim of higher growth, through phrases such as “sudden abundance created as much anxiety as sudden scarcity”. In line with Parayil, he quotes commentators who proclaimed the Green Revolution dead in the mid-1970s.<sup>31</sup> These claims are based on a focus on wheat, a relatively minor crop ranking third in acreage and production amongst food crops at that time in India, and the productivity changes are largely ascribed to HYVs developed by the Rockefeller Foundation in Mexico; the transformation and expansion of irrigation has received little comment.

The theme of inequality is central to the critique of the Green Revolution. Parayil’s overwhelmingly techno-enthusiast narrative concludes with an attack on this critique; the Green Revolution’s critics he claims, are taking on the “wrong enemy”. Income inequality, the chief negative outcome of the Green Revolution had little to do with technology but with policies relating to taxation, subsidies, credit and wages; in any case according to him, inequality was slowly decreasing in the Green Revolution areas.<sup>32</sup> Perkins mentions in passing the considerable disquiet over the regional and class inequalities inherent in the new strategy,<sup>33</sup> which Cullather thinly expands upon. Cullather also mentions the inflation-fuelled leftist uprisings in Asia in the 1970s as a consequence of inequality and the considerable disquiet in international development organisations over the same.<sup>34</sup> But exploration of the crucial question of inequality has largely been left to polemicists such as Vandana Shiva who focus on its consequences.<sup>35</sup> There is scarce exploration of the evolving theories in development studies which made inequality acceptable in agricultural policy making, whether the application of these theories built inequality into technology choice and how policy makers grappled with and attempted to mitigate rising inequality. In the domain of intellectual history, studies of the Green Revolution have largely focussed on the shift in national priorities from

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<sup>30</sup> Perkins, *Geopolitics and the Green Revolution*, p. 245.

<sup>31</sup> Cullather, *Hungry World*, p. 236.

<sup>32</sup> Parayil, “The Green Revolution in India”, p. 754.

<sup>33</sup> Perkins, *Geopolitics and the Green Revolution*, p. 230.

<sup>34</sup> Cullather, *Hungry World*, pp. 239-244.

<sup>35</sup> Vandana Shiva, *The Violence of the Green Revolution: Third World Agriculture, Ecology and Politics* (London, 1991), pp. 82-121.

industry to agriculture and Cullather has given the best overview of the same though he too has neglected to study shifts in thinking about how agriculture was to be developed with the increased resources allocated to it.<sup>36</sup>

Further, these histories have largely focussed on the role of the US and Indian governments and the Ford and Rockefeller Foundations, not fully appreciating both the advisory and hands on role of the World Bank and Indian financial institutions which were crucial in providing credit to cultivators for agricultural development. Finally, their focus has been on the process of innovation, technology adoption and policy change, giving no indication of the scope of logistical challenges involved in agricultural development and building of food-security systems.

Historical accounts of Indian agriculture have shown some scepticism about Green Revolution claims. In his economic history of colonial and postcolonial India published in 1988, Dietmar Rothermund has argued that the growth rate of agricultural production in the 1950s was not negligible compared to the “much-advertised Green Revolution” after the mid-1960s though this growth came *entirely* from expansion in area; thus deserving of the title “static agriculture”.<sup>37</sup> According to him, the Green Revolution “changed the record only in terms of a rapid growth of wheat” and at the macroscale, all that changed was that production growth was led by yield growth rather than cultivated area expansion.<sup>38</sup> Equally significantly, his chapter length account of the Green Revolution period does not at all mention the new seeds but emphasizes the importance of irrigation in reducing dependence on the monsoon.<sup>39</sup>

Tirthankar Roy has made the case for looking beyond institutional and class-related causes to explain the interwar Indian agrarian crisis, arguing for a need to examine the constraints (particularly those of an environmental nature) that limited returns on private investment in agriculture. According to him, factors limiting growth included missing markets for equipment, lack of cheap credit, low use of organic fertilizer and the high expense and uncertain return of investment on wells for irrigation.<sup>40</sup> The last was the

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<sup>36</sup> Cullather, *Hungry World*, pp. 146-152.

<sup>37</sup> Dietmar Rothermund, *An Economic History of India: From Pre-Colonial Times to 1986* (London, 1988), p. 137.

<sup>38</sup> Rothermund, *An Economic History of India*, p. 137. Emphasis added.

<sup>39</sup> Rothermund, *An Economic History of India*, pp. 141-147.

<sup>40</sup> Tirthankar Roy, "Roots of Agrarian Crisis in Interwar India: Retrieving a Narrative", *Economic and Political Weekly* (2006) **41**: 5389-5400.

most important obstacle to the transformation of agriculture. Not only were wells expensive to sink outside of riparian Northern India, but the risk of failure and the cost of raising water was high. He has mentioned a government programme to supply cultivators with mechanical pumps in Madras, and noted that the spread of such pumps was limited before the cheap electric power was available.<sup>41</sup>

While Roy's focus is on the interwar period, he has made several pertinent observations about the Green Revolution. Perhaps the most important of these is that growth rates of yields and irrigated area between 1970 and 2000 were not substantially higher than between 1950 and 1970. Poverty reduction was however faster in the later period as the irrigated area grew faster than population and this growth came from subsidies for the more democratic groundwater-based irrigation. Further, he has noted that as the fundamental obstacle to agricultural growth in the subcontinent was poor natural resource endowment, any agricultural policy that has worked at *any* time has involved substantial commitment of public resources to irrigation; in that sense whether a breakthrough happened in 1950 or 1970 is immaterial. Finally he has noted that while HYVs were not available in the 1920s, even traditional seeds were then operating well below their potential; indeed he has noted that substantial yield transformation was possible with the right combination of water, manure and traditional seeds. Thus to him, that it was well possible that had a concerted effort been made to reduce the cost of private investment, an "indigenous Green Revolution" would have occurred much earlier.<sup>42</sup> A rethinking of the Green Revolution has also been suggested by Jon Harwood who has brought issues of technology and inequality to the fore by focusing on the rise and fall what he calls "peasant friendly plant breeding". He argues that there are policy lessons to be had for present day practitioners of agricultural development from the Central European "Green Revolution" that took place in the late nineteenth and early twentieth century, as well as from colonial-era agricultural development efforts; the latter suggestion is of particular relevance to this thesis. While his study of Central European agricultural development focusses on plant breeding, he has pointed to the importance of agricultural improvement efforts other than plant breeding; indeed, he has used his study to argue that the Green Revolution package was not the only way to boost productivity.<sup>43</sup> In engaging with the

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<sup>41</sup> Tirthankar Roy, "Roots of Agrarian Crisis in Interwar India", pp.5396-5397.

<sup>42</sup> Tirthankar Roy, "Roots of Agrarian Crisis in Interwar India", pp. 5398-5399.

<sup>43</sup> Harwood, *Europe's Green Revolution*, p. 124.

critique of the Green Revolution, he has emphasized how the new varieties' massive requirement of water precluded their adoption by small farmers,<sup>44</sup> and has also mentioned the unsustainable mining of groundwater this has resulted in.<sup>45</sup> He has pointed out the importance of extension infrastructure in addition to research, and has rightly argued that the neglect of this aspect by both donors and governments was in part responsible for the rise in inequality.<sup>46</sup> While he has argued that the public sector research that underwrote the Green Revolution differs fundamentally from the present day research into GM crops which is governed by the profit motive of the private sector, he has failed to fully recognize the centrality of the private profit motive in the Green Revolution of the 1960s and 1970s.<sup>47</sup>

### **Historiography of Irrigation**

In *Oriental Despotism: A Comparative Study of Total Power*, Karl Wittfogel argued that the social organization required to manage large-scale interventions into natural hydraulic regimes for irrigation have been closely associated with the concentration of power in elite hands; this was in fact an explanation for how absolutism in the orient was more comprehensive and brutal than in western societies.<sup>48</sup> Attempts to generalize the insight of Wittfogel's study of China have seldom borne fruit<sup>49</sup> and the general idea of a "hydraulic society" is a somewhat unfashionable concept in academia today. Nevertheless, an obsession with the relationship between large-scale systems, power and social hierarchy continues to be central to studies of irrigation and the big dam is central

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<sup>44</sup> Harwood, *Europe's Green Revolution*, p. 121.

<sup>45</sup> Harwood, *Europe's Green Revolution*, p.4.

<sup>46</sup> Jonathan Harwood, "Peasant Friendly Plant Breeding and the Early Years of the Green Revolution in Mexico", *Agricultural History* (2009) **83**: 384-410.

<sup>47</sup> Jonathan Harwood, "Rethinking the historiography of the Green Revolution: whatever happened to comparative analysis?", paper presented at the History of Science, Technology and Medicine Seminar at King's College, London on 29<sup>th</sup> April 2015.

<sup>48</sup> Karl Wittfogel, *Oriental Despotism: A Comparative Study of Total Power* (New Haven, Ct., 1957). Wittfogel's ideas owed much intellectual debt to Marx's idea of an Asiatic Mode of Production and Weber's conception of pre-modern India and China as "hydraulic-bureaucratic official states"; for an excellent overview of the evolution of Wittfogel's scholarship, see Donald Worster, *Rivers of Empire: Water, Aridity and The Growth of the American West* (New York, 1985), pp. 22-29.

<sup>49</sup> For example, Irfan Habib, *The agrarian system of Mughal India, 1556-1707* (New Delhi, [1963] 1999) argues that there was little evidence to support the belief the state's control of irrigation works was a prominent feature of agrarian life in Mughal India.



to our picture of water and modernity This is exemplified by Donald Worster's study of water in the American West which he explicitly grounds in the Wittfogelian tradition (albeit with some qualification), arguing that large dams and canal systems have edged out the small farmer in favour of large capitalist farms and led to a redistribution of power to economic and bureaucratic elites; a state of affairs he contrasts with the more localized means of irrigation usually favoured by the native Americans.<sup>50</sup> This association of modernity with large scale, centralized forms of water governance is also exemplified in James Scott's influential book, *Seeing Like a State* where he argues that "legibility" is fundamental to the exercise of the high-modernist developmental power of the centralized state; while irrigation is not one of his case studies, he explicitly contrasts (in tabular form) the illegibility of "local customary use" and "local irrigation societies" with the legibility of the "centralized dam" and "irrigation control".<sup>51</sup> Most studies of water in the twentieth century then, focus on large-scale surface systems such as high dams.

In the Indian case, the focus has been on the large perennial canal irrigation systems pioneered by the British in India. The historical study of canal irrigation in India was arguably pioneered by Elizabeth Whitcombe in the early 1970s with her book on the United Provinces, which challenged the then prevailing notion of colonial irrigation as having had an overwhelmingly positive impact. On the contrary, according to her, canal irrigation was accompanied by grave ecological consequences such as waterlogging and soil salinization; it merely created pockets of prosperity in a sea of depressed peasantry.<sup>52</sup> This was countered a decade later by Ian Stone, who argued that Whitcombe had overstated the negative impact of surface irrigation; to him, canal irrigation was an "appropriate technology" which released overwhelmingly positive expansionary forces. To him, canal irrigation was the cause of the dynamism of agriculture in western UP as compared to other parts of the province.<sup>53</sup>

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<sup>50</sup> Worster, *Rivers of Empire*.

<sup>51</sup> Scott, *Seeing Like a State*, p.220.

<sup>52</sup> Elizabeth Whitcombe, *Agrarian Conditions in Northern India Volume One: The United Provinces under British Rule 1860-1900* (Berkeley, Ca., 1972).

<sup>53</sup> Ian Stone, *Canal Irrigation in British India: Perspectives on technological change in a peasant economy* (Cambridge, 1984).

Larger arguments in the irrigation historiography have since moved on from whether canal irrigation had a positive or negative impact to the political, economic and social aspects of these systems. In his study of the Punjab canal colonies, Imran Ali has argued that there was a tension between the economic and political agendas of the colonial dispensation. Thus economic growth was accompanied by underdevelopment as the development of capitalism was defeated by the colonial state's embrace of archaic social institutions.<sup>54</sup> On similar lines, David Gilmartin has argued that the experience of canal irrigation in Punjab was characterized by tensions between what he called "imperial science" and "scientific empire". While the former enabled the British to take control of nature and expand its revenue potential; the latter, in forcing the British to adapt practices to local political hierarchies and to the exploitative character of colonialism itself, constrained the transformative potential of large irrigation systems.<sup>55</sup> Finally, the Punjab case has also been studied by M. Muzaffakarul Islam who has argued that the British built the Punjab's canals not for famine prevention or due to a "Paternalistic ethos" but to expand the tax base, better equip India to fulfill her role as a supplier of agricultural raw materials and to pay for imports from Britain. Canal irrigation did result in higher yields, but the performance was suboptimal due to the wasteful and inefficient use of water. Full-scale capitalism failed to develop due to the existence of a vast pool of small farmers and labourers who would pay a high price for tenancy rather than work as wage labour; this proved more profitable to large land owners than hiring labour.<sup>56</sup>

We also have two chapter length overviews of colonial irrigation history more generally. In a nod to the "oriental despotism" idea, Headrick has argued that the British were driven by the "logic of benevolent tyranny" in their pursuit of gigantic irrigation schemes in India and Egypt.<sup>57</sup> Whitcombe has also written a chapter-length overview of colonial irrigation in which her essential argument is that despite some impressive achievements,

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<sup>54</sup> Imran Ali, *The Punjab Under Imperialism 1885-1947* (Princeton, NJ, 1988).

<sup>55</sup> David Gilmartin, "Scientific Empire and Imperial Science: Colonialism and Irrigation Technology in the Indus Basin", *The Journal of Asian Studies*, (1994) **53**: 1127–48.

<sup>56</sup> M. Muzaffakarul Islam, *Irrigation, Agriculture and the Raj: Punjab 1887-1947* (New Delhi, 1947).

<sup>57</sup> Daniel Headrick, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850-1940* (New York, 1988), pp. 171-208.

the narrow financial viewpoint taken by the administration prevented greater development of India's water resources.<sup>58</sup>

These histories of irrigation all end with the completion of the last great colonial irrigation works in the interwar years and there is hardly any work which take the story forward into the postcolonial years. The scant work studying water resources in the later period focus on the ideological and rhetorical aspects of the big dams, the construction of which became prominent in Nehruvian India. In an excellent study of the Tennessee Valley Authority and the Damodar Valley Corporation it inspired in India, Daniel Klingensmith seeks to explore how dams have been politically imagined in the twentieth century and argues that proponents of dams were well aware of their potential for environmental destruction but overestimated their ability to deal with the consequences.<sup>59</sup> In his study of the Hirakud dam, Rohan D'Souza thus argues that despite being celebrated as an apolitical consensus, TVA-style Multipurpose River Valley Development was introduced in India in the 1940s as the colonial state, Indian capital and sections of the nationalist leadership were crafting a new rhetoric for continued rule.<sup>60</sup> These works on dams tell us little about the concerns of irrigation and agriculture; indeed a careless reading might suggest that irrigation as a goal had little role to play in India's commitment to big dams. The arrival of big dam technology from America is thus seen as a decisive rupture in the history of water management in India, rather than merely as one step in the long history of intervention in natural hydraulic regimes.<sup>61</sup>

All these works have concentrated on large-scale projects. Groundwater irrigation has largely been neglected in accounts of irrigation in India and elsewhere, perhaps because of the perception, to quote Donald Worster, that "Subsurface deposits often require little social organization" and, by extension, were either uninteresting or might conflict with the association of modernity with centralized forms of water governance.<sup>62</sup> In the

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<sup>58</sup> Elizabeth Whitcombe, "Irrigation" in Meghnad Desai and Dharma Kumar (eds.), *The Cambridge Economic History of India* (2005), pp. 677-737.

<sup>59</sup> Daniel Klingensmith, *One Valley and a Thousand: Dams, Nationalism and Development* (New Delhi, 2007).

<sup>60</sup> Rohan D'Souza, "Damming the Mahanadi river: The emergence of multi-purpose river valley development in India (1943-46)." *Indian Economic & Social History Review* (2003) 40: 81-105.

<sup>61</sup> Klingensmith, *One Valley and a Thousand* and D'Souza, "Damming the Mahanadi river"

<sup>62</sup> Worster, *Rivers of Empire*, p 313.

American case, we have two book length works studying the history of irrigation from the Ogallala aquifer on the US High Plains.<sup>63</sup> In the Indian case, we have only a single brief paper focused on well irrigation. In Gujarat, where there were no large canal systems in competition, the colonial government incentivized the construction of irrigation wells, and the history of well irrigation in that region from pre-colonial to near contemporary times has been studied by David Hardiman.<sup>64</sup> He notes that contrary to a (then) recent think-tank report celebrating traditional water management structures,<sup>65</sup> merchant and usurer capital were influential to their economy even in pre-colonial times. He details British incentives for the construction of wells in the late nineteenth century and early twentieth centuries and argues that it would be incorrect to see the reasons for the present crisis in access to water to the commercialization of agriculture and the rise of economic individualism during the colonial period. According to him, colonial rule did not destroy traditional hierarchical communities, but by granting property rights in land and water, British rule strengthened the basis of local elites' power.<sup>66</sup>

Despite not being the focus, groundwater does figure in the historiography of colonial Indian irrigation as well. For example, both Whitcombe and Stone agreed that that canal irrigation, due to its low cost, led to a decline in irrigation from wells that was traditional in western UP. Whitcombe argued that well irrigation was efficient in its use of water as it was constrained by the availability of labour and draught power which prevented over cultivation and consequent loss of soil fertility; in addition, well irrigation did not lead to grave environmental problems like waterlogging which were closely associated with canals.<sup>67</sup> However, Stone argued that by releasing the labour and draught power that would otherwise have to be employed for well irrigation, canals enabled intensified cultivation that would have been impossible with well irrigation.<sup>68</sup> The neglect and

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<sup>63</sup> See John Opie, *Ogallala: Water for a Dry Land* (Lincoln, Ne, 1993) and Donald E. Green, *Land of the Underground Rain: Irrigation on the Texas High Plains, 1910-1970* (Austin, TX, 1973).

<sup>64</sup> David Hardiman, "Well Irrigation in Gujarat: Systems of Use, Hierarchies of Control", *Economic and Political Weekly* (1998), **33**: 1533-1544.

<sup>65</sup> Anil Agarwal and Sunita Narain, *Dying Wisdom: Rise, Fall and Potential of India's Traditional Water Harvesting Systems* (New Delhi, 1997).

<sup>66</sup> Hardiman, "Well Irrigation in Gujarat".

<sup>67</sup> Whitcombe, *Agrarian Conditions*.

<sup>68</sup> Stone, *Canal Irrigation*.

decline of groundwater irrigation in the colonial period has also been noted by Imran Ali who has devoted a brief section to lift and tubewell irrigation in Punjab between 1910 and 1930 mostly centred on the efforts of the private agriculturalist Sir Ganga Ram. Ali has attributed the failure to develop tubewell irrigation to the slow spread of electric power and to the reliance of the colonial state on intermediaries such as Sir Ganga Ram for agricultural improvement efforts.<sup>69</sup> While Islam has shown that groundwater irrigation saw a resurgence in early twentieth-century Punjab and thus argued that the picture of decline gleaned from the UP studies could not be generalized,<sup>70</sup> the overall picture of small-scale irrigation in the historiography is still one of governmental neglect if not decline as suggested by Whitcombe's overview of colonial irrigation.<sup>71</sup>

These passing references scarcely do justice to the importance of groundwater irrigation in India, which leads the world in the volume of groundwater extracted annually; irrigation from groundwater accounts for two thirds of India's irrigated acreage. Such is the perceived importance of groundwater to the Indian economy that a World Bank estimate in the 1990s suggested that the ability to extract groundwater for irrigation contributed 10% to India's GDP.<sup>72</sup> The economist Tushaar Shah has argued that the larger story of late twentieth-century irrigation in south Asia is one of a regression from the largest centrally managed surface irrigation system in to world to an anarchy of privately-owned pumps.<sup>73</sup> To a lesser extent, this has been a global trend led by northwestern India, the south China plains and the US high plains. The neglect is to be lamented not merely because tubewells became more important in the postcolonial period which has been the subject of few histories; not only was the tubewell arguably central to postcolonial agricultural development, but as I will detail, colonial India saw the first large-scale use of tubewells anywhere in the world.

## **History of Science and Technology in India**

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<sup>69</sup> Ali, *The Punjab Under Imperialism*, pp. 218-222.

<sup>70</sup> Islam, *Irrigation, Agriculture and the Raj*.

<sup>71</sup> Whitcombe, "Irrigation".

<sup>72</sup> World Bank, *India- Water resources management sector review: Groundwater regulation and management report* (Washington, DC, 1998).

<sup>73</sup> Tushaar Shah, *Taming the Anarchy: Groundwater Governance in South Asia* (Washington, DC, 2009).

There exists a rich historiography of science in colonial India and it is well recognized that science is central to the understanding of colonialism and of modern India more generally. This historiography, which is concerned with the nature of the colonial encounter addresses itself first to the question of “Science and Empire” and only then with Indian history.<sup>74</sup> The scholarly study of this question of how science moves from the metropolis to the colony is traditionally dated to Basalla’s three stage diffusion model.<sup>75</sup> It began to be challenged from the late 1970s onwards with the backlash against modernization theory and the rise of dependency theory; this challenge has been central to the historiography.

This challenge takes the form of several non-mutually exclusive strategies. To begin with, it emphasizes the concept of colonial science as embodying the specificities of the colonial relationship in any given locality and the struggles and negotiations that characterized the growth and spread of science in India. By demonstrating that the economic needs of the colonial government shaped the work of scientists, it argues that science was as much constructed in the colonies as “Western science” was spread.<sup>76</sup> Another strategy stresses the agency of Indians by emphasizing the struggle, resistance and subversion inherent in reinterpretation of Western science in the Indian context.<sup>77</sup> Yet another position emphasizes that syncretism was central to the evolution of science in the colonies which was a marriage between Western and Indian practices; as Kapil Raj has noted, South Asia was an active though unequal participant in the world order of knowledge.<sup>78</sup>

The intellectual, the rhetorical and the discursive, rather than the material have dominated the historiography of technology in the twentieth century; this is in contrast to studies of the genesis and impact of technologies such as large-scale irrigation, the railways and the telegraph in earlier periods. The concern of historians studying this period is with the

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<sup>74</sup> This point is also made by Aparajith Ramnath, *Engineers in India: Industrialisation, Indianisation and the State, 1900-47* (Unpublished Ph.D. dissertation, Imperial College, London, 2012).

<sup>75</sup> George Basalla, “The Spread of Western Science”, *Science* (1967) **156**: 611-22.

<sup>76</sup> See for example Deepak Kumar, *Science and the Raj, 1857-1905* (Oxford, 1995) and David Arnold, *Science, Technology and Medicine in Colonial India* (Cambridge, 2000).

<sup>77</sup> See for example Gyan Prakash, *Another Reason: Science and the Imagination of Modern India* (Princeton, 1999).

<sup>78</sup> Kapil Raj, *Relocating Modern Science: Circulation and the Construction of Knowledge in South Asia and Europe, 1650-1900* (New York, 2007).

interlacing of science, technology, modernity and nationalism and scholarly work is centred on analysis of the discourse by scientists and nationalists. Gyan Prakash thus argues that for the colonial authorities, India's resources were to be acted upon by the "technologies of government"; nationalists' critique of colonial rule rested on the idea that the British had not gone far enough in developing India through science, technology and industrialization. Gandhi, whose views lay entirely outside the spectrum of conventional ideas in his trenchant critique of modernity was sidelined by dominant nationalists and thus began the love affair with science and technology in Nehruvian India and beyond.<sup>79</sup>

However, the material must play an important role in studies of technology, for doing may illustrate more significant continuities than analysis of sharply polarized opinions might suggest. Further, bridging the history of colonial technology and postcolonial "development" may help challenge the idea, exemplified in the works on the Green Revolution, that the latter had origins exclusively in interwar United States. But, as Christopher Baker has argued, the postcolonial government inherited considerable "work in progress" from the colonial state.<sup>80</sup> Studying a period that cuts across the divide of 1947 may help test our assumptions both about colonial technology and postcolonial development. There is a growing interest in emphasizing the colonial origins of development, best exemplified in Joseph Morgan's recent work which builds upon the studies of Helen Tilley in Africa and Suzanne Moon in the Dutch East Indies.<sup>81</sup> His work, which is centred on the growing networks of expertise around the Colonial Office in London (which mostly engaged with Africa) argues that scientific experts rose to

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<sup>79</sup> Prakash, *Another Reason*. Other works which engage with this period such as David Arnold, *Science, Technology and Medicine in Colonial India* (Cambridge, 2000) and Deepak Kumar, "Reconstructing India: Disunity in the Science and Technology for Development Discourse, 1900-1947", *Osiris* (2000) 15: 241-257 are also mostly based on analysis of discourse.

<sup>80</sup> Christopher Baker, *An Indian Rural Economy, 1880-1955: The Tamilnad Countryside* (Oxford, 1984).

<sup>81</sup> Joseph Morgan Hodge, *Triumph of the Expert: Agrarian Doctrines of Development and the Legacies of British Colonialism* (Athens, Oh, 2007). Also see Suzanne Moon, "Empirical knowledge, Scientific Authority and Native Development: The Controversy over Sugar/Rice ecology in the Netherlands East Indies, 1905-14", *Environment and History* 10: 59-81 and Helen Tilley, *Africa as a Living Laboratory: Empire, Development and the Problem of Scientific Knowledge* (Chicago, 2011).

unparalleled authority under late British imperialism which was an imperialism of science; these experts prefigured ideas of restraint and long-term sustainability.<sup>82</sup>

With the exception of the work on dams which I have previously discussed, histories of science and technology which engage substantially with postcolonial India have privileged scientific *research* and independent India's engagement with the "cutting edge" science and technology fields of the day; mostly (nuclear) physics.<sup>83</sup> But in an attempt to provide a corrective to this focus on the big, there is a growing interest in studying "everyday technology" in the non-western world; this was the subject of a special issue of *Modern Asian Studies* in 2012 as well as a recent book by David Arnold.<sup>84</sup>

In his study of bicycles, typewriters, sewing machines and rice mills, Arnold argues that a study of these "small machines" can enable the discipline to move away from a chronicling of British rule (that apparently comes from a focus on big technologies such as railways and large-scale irrigation schemes) to a study of the "inner histories of India". The intimacy offered by "everyday technology" associated as it was with myriad forms of appropriation, modification and cultural context he argues, will also help counter the "diffusionist model".<sup>85</sup> While offering a rare and interesting account of small machines which have thus far escaped the attention of historians of India, Arnold's work has little to offer by way of any larger arguments. Combating diffusionism has been the central project of the historiography of colonial-era technology for a quarter of a century now and it is unclear what a turn towards the small can add to that project. While the historiography of technology in colonial India and beyond must indeed address issues of culture and society as much as it addresses questions of the state, it does not follow that the history of small machines must be a history of society alone, or indeed that the history of big technology be a history of the state alone. While Arnold does not quite suggest small technology as a means of subversion, the state is largely absent from his work

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<sup>82</sup> Hodge, *Triumph of the Expert*.

<sup>83</sup> See for example, Itty Abraham, *The making of the Indian atomic bomb: Science, secrecy and the postcolonial state* (London, 1998), Jahnavi Phalkey, *Atomic State: Big Science in Twentieth-Century India* (New Delhi, 2013), Robert S. Anderson, *Nucleus and nation: scientists, international networks, and power in India* (Chicago, IL, 2010), and Shiv Visvanathan, *Organizing for Science: The Making of an Industrial Research Laboratory* (Oxford, 1985).

<sup>84</sup> David Arnold, *Everyday Technology: Machines and the Making of India's Modernity* (Chicago, 2013) and *Modern Asian Studies* (2012) 46.

<sup>85</sup> Arnold, *Everyday Technology*, pp. 3-12.



except as an occasional regulator and user of small machines. In an epilogue titled “The God of Small Things” he stresses the importance of small technology by referring to the small pumps “responsible for the greening of so much of the Indian countryside” in contrast to Nehru’s dams which have become mired in high environmental and social costs.<sup>86</sup> The special issue of *Modern Asian Studies* also carries an article about small pumps in Vietnam which privileges the role of local enterprise and innovation.<sup>87</sup> But these works scarcely do justice to the importance of these machines and their centrality in a state-sponsored scheme of agricultural transformation.

David Edgerton has argued that rather than replacing a focus on “high-tech, masculine, industrial technologies” with a focus on “the low tech, the feminine and the domestic”, we need to engage with both to get a sense of the “material basis of human existence”,<sup>88</sup> though he is often misunderstood as arguing for studying the small rather than the large. This thesis thus focusses is not on small-scale technology (like tubewells) alone, but also on the concurrent investment in big dams. The issue is *which technologies have which effects*, and in much literature particular technologies are systematically overemphasized, usually some (but not all) novel technologies. In the case of agricultural development the HYVs have been gross over emphasized, neglecting fertilizer and especially tubewells; furthermore a whole series of economic innovations have tended to be ignored. Finally, it is guided by another (lesser known) argument of David Edgerton’s; that the idea of a world at its “technological limits” which is often used by technology promoters is usually erroneous.<sup>89</sup> This thesis thus engages critically with the arguments of technology promoters rather than state them as fact which is too often the case in histories of technology in general and of the Green Revolution in particular.

However, excessive focus on innovation and context that has led to the privileging of “the question of technology”. As David Edgerton has argued, we need a new post contextualist history of technology that seeks to address historical questions and produce a new understanding of historical events, rather than merely seeking to contextualize technology

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<sup>86</sup> Arnold, *Everyday Technology*, p. 173.

<sup>87</sup> David Biggs, “Small Machines in the Garden: Everyday technology and Revolution in the Mekong Delta”, *Modern Asian Studies* (2012) **46**: 57-70.

<sup>88</sup> Edgerton, “Creole technologies”, p. 82.

<sup>89</sup> David Edgerton, “The contribution of research to humanity”, in Takeshi Kinoshita (ed.), *Science and Society: research for the next generation - JSPS-UK Research Council Symposium* (Northampton, 1999), pp. 46-49.

with existing known histories.<sup>90</sup> This thesis is thus concerned not with irrigation alone but with rethinking the changing nature of the state and economy in twentieth-century India.

### History of Contemporary India

Despite the oft-lamented fact that histories of India end in 1947,<sup>91</sup> that line has been breached more frequently than is acknowledged. The first significant general history of independent India, *India Since Independence* (published in 1999) authored by Bipan Chandra, Mridula Mukherjee and Aditya Mukherjee, a group of historians at the Jawaharlal Nehru University displayed some of Rothermund's scepticism. Thus they claim (albeit with little more than outline figures for expenditure) that the Nehruvian state did not neglect agriculture. Crucially, they recognize that the impact of the Green Revolution was not due to production growth alone but a rapid increase in *marketable surplus* as gains were mostly made in regions already producing more than they consumed; it was this rather than aggregate production growth which enabled the government to procure food and build buffer stocks.<sup>92</sup>

But despite this recognition, the authors are in agreement with the argument that by the 1960s, growth through traditional means was reaching its limits which was overcome by "critical scientific breakthroughs".<sup>93</sup> According to them, the new strategy helped India *maintain* growth rates of production achieved in the 1950s and the Green Revolution put an end to "India's 'begging bowl' image".<sup>94</sup> Thus this work largely celebrates the Green Revolution's achievements in food production and poverty reduction.

In the absence of substantial historical work, political scientists are usually relied upon to provide a picture of the Indian state. Some of these works effectively count as primary observations if not actor accounts; for example one of the best known political scholars of India is Francine Frankel who came to study the Green Revolution in the 1960s, working closely with institutions such as USAID and the World Bank, and this thesis uses

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<sup>90</sup> Edgerton, "Creole technologies" p. 82.

<sup>91</sup> See for example Ramachandra Guha, "The Challenge of Contemporary History", *Economic and Political Weekly* (2008) **43**: 192-200.

<sup>92</sup> Bipan Chandra, Mridula Mukherjee and Aditya Mukherjee, *India Since Independence* (New Delhi, 1999), pp. 571-583. Emphasis added.

<sup>93</sup> Chandra *et. al*, *India Since Independence*, p. 572.

<sup>94</sup> Chandra *et. al*, *India Since Independence*, p. 580.

(and engages substantially) with her book on the Green Revolution.<sup>95</sup> In the late 1970s, Frankel also wrote a detailed study of India's political economy. Her central argument is that India's political framework was designed to uphold the interests of the propertied classes; as key subjects such as land reforms were left to the provinces which were politically controlled by the landed elite, any revolution was necessarily gradual. From the early 1960s, Nehru's authority declined and his successor Lal Bahadur Shastri shifted the balance even more in favour of provincial power and landed agrarian interests.<sup>96</sup>

Lloyd and Susan Rudolph's *In Pursuit of Lakshmi* (published in 1987) also serves as a reference work on the Indian State. Rural class polarization, they argue, has been limited by the preponderance of the "bullock capitalists"; cultivators who benefited from the Green Revolution but largely rely on family, rather than wage labour.<sup>97</sup> With the bullock capitalists as a hegemonic rural class (who they emphasize, are not *kulaks*) uniting the interests of capital, management and labour, class politics has not made much headway in the countryside; this the emergence of this class has helped strengthen national centrist politics. The Rudolphs place much emphasis on the role of these bullock capitalist as a "demand group" which has played an increasingly important role in India politics since the late 1970s, but their work tells us little that is unknown about the processes of policy and technical change that made this class powerful.<sup>98</sup>

Another influential work of political science is Sunil Khilnani's *The Idea of India* which like *India Since Independence* was published around the 50<sup>th</sup> anniversary of decolonization. In a chapter titled "Temples of the future" (after the epithet Nehru gave to big dams), Khilnani starts with the claim that "India in the 1950s fell in love with the idea of concrete" and says that half a century later, most agree that the Nehruvian modernist vision was grandiose, irrelevant and destructive; dams have come to be seen as a "fantasy insensitive to ecological limits" which turned citizens into refugees.<sup>99</sup> His engagement with the Nehruvian period though, focusses mostly on planning for

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<sup>95</sup> Francine Frankel, *India's Green Revolution: Economic Gains and Political Costs* (Princeton, NJ, 1971).

<sup>96</sup> Francine Frankel, *India's Political Economy 1947-1977: The Gradual Revolution* (Princeton, NJ, 1978).

<sup>97</sup> Lloyd I. Rudolph and Susan Hoeber Rudolph, *In Pursuit of Lakshmi: The Political Economy of the Indian State* (London, 1987), pp. 49.

<sup>98</sup> Lloyd I. Rudolph and Susan Hoeber Rudolph, *In Pursuit of Lakshmi*, pp. 49-54.

<sup>99</sup> Sunil Khilnani, *The Idea of India* (New Delhi, 1997), pp.61-62.

industrialization; on agriculture he argues that the “agricultural policies of the Green Revolution managed to break India’s dependence of food imports” in the 1970s.<sup>100</sup>

Finally, we have the best known history of independent India; Ramachandra Guha’s popular *India After Gandhi*. A magisterial work exceptional in scale, it attempts to make few specific arguments, but references within supports the general picture of Nehruvian neglect of agriculture and a Gandhian critique of his big dams<sup>101</sup> as well as a necessary and successful Green Revolution.<sup>102</sup>

### **Structure of the thesis**

The thesis consists of seven chapters covering the period between 1900 and 1980. The first chapter focusses on the story of the classic Green Revolution sets the argument for the rest of the thesis. It argues that a breakthrough in the land productivity of foodgrains actually took place around 1950 and the productivity gains in wheat from the mid-1960s (and later, in rice) had to do more with the transformation and expansion of irrigation with tubewells rather than new seed varieties.

The next three chapters tell the story of irrigation development in India from about 1900 to the mid-1960s when the emphasis was on publicly-owned systems. Chapter 2 explores the colonial origins of tubewell irrigation and presents an overview of state stimuli to groundwater irrigation in late colonial India taking the Indian Irrigation Commission of 1901-03 as its starting point. The bulk of the chapter is centred on the career of Sir William Stampe, a British engineer who was the force behind an important rural irrigation and public tubewell programme in interwar India and served as Irrigation Adviser to the Government of India during the war. Besides demonstrating the attention paid by the colonial government to small-scale irrigation works, I argue that colonial engineers such as Stampe developed a small-scale, rural-agricultural vision for technology in India which was in sharp contrast to the large-scale, urban-industrial vision of nationalist technocrats. Chapter 3 provides an overview of irrigation planning in India between 1950 and 1965 with a focus on dams. I argue that Nehruvian India devoted much public investment to irrigation (and by extension, to agriculture), but the push for the same came from the

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<sup>100</sup> Khilnani, *Idea of India*, p.93.

<sup>101</sup> Ramachandra Guha, *India After Gandhi: The History of the World’s Largest Democracy* (London, 2007), p. 223.

<sup>102</sup> Guha, *India After Gandhi*, p. 345.

states rather than the central technocratic elite. I further argue that India's commitment to big dams was not merely a result of the ideological example of the TVA but of long held aspirations of Indian irrigation engineers. In Chapter 4, I shall show how postwar India took up not just large dam projects but also public tubewell irrigation schemes; large projects resulted from the execution of Stampe's grand plans after his departure from India and these were scaled up with American aid in the 1950s.

Chapter 5 traces the evolution of India's New Agricultural Strategy in the mid-1960s and argues that it was underpinned by Theodore Schultz's theory of the rational peasant; ideas of peasant rationality were central to the choice of the dwarf wheat varieties. Chapter 6 tells the story of how World Bank advice based on these ideas, together with unprecedented drought, a crisis of public finances and new ideas about the water needs of crops put the private tubewell at the centre of the discourse and practice of irrigation in India in the mid-1960s. The final chapter focusses on the activities of a public sector financial company called the Agricultural Refinance Corporation which played a central role in promoting groundwater irrigation through cheap loans to cultivators; an effort in which it was massively supported by the World Bank.

## **Chapter 1: Green Revolution?**

The late 1960s is where a breakthrough in twentieth-century Indian food production is typically placed. The key claims of this “Green Revolution” are that there was remarkable growth in the production and yields of foodgrain and that these productivity gains were largely due to the introduction of High Yielding Varieties (HYVs) of seeds. In this chapter, I shall challenge both these claims and argue that the revolutionary transformation of production and yields of foodgrains began around 1950. The 1950s saw India’s best performance in the growth rate of production and yield of foodgrains; the 1960s and 1970s were in fact a period of slower growth, though the performance was much better than in any period during the colonial era.

The standard periodization stems from a focus on a technological transformation in the 1960s in production of wheat, a relatively minor part of India’s food basket. I shall argue that while it was indeed the case that India’s wheat production and yields attained a new plane in the late 1960s, it merely followed a less spectacular revolution in the 1950s. HYVs developed by the Rockefeller Foundation in Mexico are conventionally seen as the main cause of this Green Revolution. I shall however argue that the technology central to this transformation in the 1960s was irrigation-expansion through private tubewells rather than new seed varieties. In fact, inefficient in their use of fertilizer, the HYVs likely impeded the efficient growth of wheat yields in the country.

I shall then turn attention to rice which has received scant historical attention in the Indian context despite being preponderant in India’s food basket. I will show that rice production too had two underwent two revolutions. While the first which started towards the end of the War was more spectacular than the corresponding revolution in wheat; the second began later (around the mid-1970s) and was less spectacular than the second wheat revolution. These growth spurts were interspersed by a period of slow growth in the late 1960s and 1970s, making for the low growth of overall foodgrain production in India.

I shall argue that tubewell irrigation lay at the heart of the rice revolution as well. The qualitative advantages of private tubewells over canals such as reliability and individual control played a greater role in the transformation of rice production compared to wheat where the advantage of private tubewells was mostly confined to an increase in the water supply. This they did by enabling some rice cultivators to break free of monsoon cycles and traditional irrigation schedules, thus enabling the extension of high-yielding rice

cultivation in nontraditional seasons and regions. Thus the second transformation of rice production began with the use of tubewells (installed to irrigate the wintertime wheat crop) for monsoon rice cultivation in Punjab which had never been a traditional rice-growing region. They also enabled the cultivation of rice in Bengal during the summer, an excellent season for rice cultivation but for the want of water.

Varietal improvement played a greater role in the second rice yield revolution than it did for the more spectacular revolution in wheat; for the short duration and photoperiod insensitivity of some new rice varieties enabled the expansion of rice cultivation to nontraditional seasons and areas. However, the Green Revolution in rice was seemingly disappointing as the transformation in traditional rice cultivation was slow. In large part, this was because rice was cultivated on a massive national acreage in comparison to wheat. Thus government resources were too small to effect a quick transformation in rice cultivation with a mere shift in national priorities; in any case there was no significant increase in the emphasis on rice production in the 1960s. Technologically, high quality water management was the key issue in the transformation of rice production and this proved intractable for many reasons. Canal irrigation systems in rice tracts were rudimentary and offered no means of controlling water to individual fields; watering schedules too were rigid and unpredictable. The new varieties chosen proved unsuitable to interplay of monsoon cycles and traditional irrigation schedules. The spread of private tubewells in traditional rice areas (to transform cultivation in traditional and nontraditional seasons) and was slow due to tenurial conditions and the high cost of access to water resources.

The term “Green Revolution”, with the new seeds as its central motif was coined in the United States to project the idea that overseas aid was easy and effective, at a time when foreign aid was being increasingly questioned in that country. Plant breeder Dr. Norman Borlaug was awarded the Nobel Peace Prize in 1970 and the Rockefeller Foundation quickly appropriated all credit for any increased production, forcefully claiming that the seeds alone were central to high yields. As it became clear that production gains were largely confined to wheat in northwestern India, scholarly studies only intensified their focus on new seed varieties rather than the general question of increasing production. Critics of the Green Revolution, historians among them, chose not to challenge the standard seed-centric narrative and infact attributed a wide range of social ills to the new

seeds; this was due to an obsession with the idea of recent research an innovation driving revolutionary socio-economic change.

The statistical sources for this chapter include the annual Area Production and Yield of Principal Crops in India produced by the Ministry of Agriculture. Corrections for that data series sourced from George Blyn's pioneering study of colonial India<sup>1</sup> and data from an International Food Policy Research Institute publication for the postcolonial period.<sup>2</sup> The conveniently categorized statistics on the Directorate of Rice Development's website have also been used. Other sources include the memoirs of the then Secretary of Agriculture B. Sivaraman<sup>3</sup> and of the Agriculture Minister C. Subramaniam<sup>4</sup> which are surprisingly under-used by historians considering the interesting accounts they offer of policy formation around the HYVs. The research papers and general articles of social scientists (mostly economists in the *Economic and Political Weekly*) are another source. Use is also made of technical literature; particularly a book summarizing research on dwarf wheats published in 1979 by Punjab Agricultural University plant breeder Khem Singh Gill.<sup>5</sup> Finally, extensive use is made of the annual *Economic Survey of India* published by the Ministry of Finance.<sup>6</sup>

## I

Despite the Green Revolution being the focal point of the limited historiography of agriculture in postcolonial India, we have no clear picture of its overall impact on foodgrain production. It is conventionally assumed that a Green Revolution put India's foodgrain production on a higher plane of production and productivity growth from the late 1960s onwards and histories such as those written by Perkins do little to dispel this notion, though he hints of occasional spectacular increases in production in the earlier period.<sup>7</sup> Nick Cullather's recent critical account mentions how that the CIA proclaimed

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<sup>1</sup> George Blyn, *Agricultural Trends in India, 1891-1947: Output, Availability and Productivity* (Philadelphia, Pa, 1966).

<sup>2</sup> J. S. Sarma and Vasant P. Gandhi, *Production and Consumption of Foodgrains in India: Implications of Accelerated Economic Growth and Poverty Alleviation* (Washington, DC, 1990).

<sup>3</sup> B. Sivaraman, *Bitter Sweet: Governance of India in Transition* (New Delhi, 1991).

<sup>4</sup> C. Subramaniam, *Hand of Destiny Volume 2: The Green Revolution* (Bombay, 1993).

<sup>5</sup> Khem Singh Gill, *Research on Dwarf Wheats* (New Delhi, 1979).

<sup>6</sup> Ministry of Finance, *Economic Survey of India* (New Delhi, 1978-82).

<sup>7</sup> John Perkins, *Geopolitics and the Green Revolution: Wheat, Genes and the Cold War* (New York, 1997).



the Green Revolution dead by the mid-1970s.<sup>8</sup> Parayil places the Revolution between 1965 and 1975.<sup>9</sup> Alone in providing statistical evidence to buttress the claim of a Green Revolution, Gurcharan Das does so in passing by comparing figures for production growth before and after 1945; strangely he chooses to ascribe the revolution technology and policy change in the mid-1960s.<sup>10</sup> A more critical perspective has been taken Dietmar Rothermund who argued that growth rates after the mid-1960s merely kept up with the 1950s growth rate entirely due to a spurt in the production and yields of wheat. The causes of this yield boom have almost universally been attributed to the HYVs.<sup>11</sup> Cullather hints that other factors were at play but does not detail quite what those were.<sup>12</sup> Again, Rothermund does not mention the seeds at all and stresses upon the role of booming irrigated wheat acreages.<sup>13</sup> Tirthankar Roy's paper on late colonial Indian agriculture too displays skepticism towards both the periodization and the causes of late twentieth-century productivity gain and emphasizes the centrality of irrigation to any successful agricultural policy in India.<sup>14</sup>

Little historical insight exists on the transformation in the cultivation of rice, India's most important crop, except that it too had something to do with plant breeding.<sup>15</sup> Francesca Bray has written an excellent study of rice production over hundreds of years across a wide swathe of East Asia and her book tells us much of the great challenges in the improvement of rice agriculture due to the fact that the relationship between varieties, seasons, irrigation and human society was already excellently optimized in traditional rice economies.<sup>16</sup> Her book provides no coherent story of the Indian case; while the seemingly easy revolution in rice production in the 1950s negates her argument that traditional rice

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<sup>8</sup> Nick Cullather, *The Hungry World: America's Cold War Battle against Poverty in Asia* (Cambridge, Ma, 2010), p. 252-253.

<sup>9</sup> Govindan Parayil, "The green revolution in India: A case study of technological change." *Technology and Culture* (1992) **4**: 737-756.

<sup>10</sup> Gurcharan Das, *India Unbound: From Independence to Global Information Age* (New Delhi, 2000).

<sup>11</sup> See Perkins, *Geopolitics and the Green Revolution*, and Govindan Parayil, "The green revolution in India".

<sup>12</sup> Cullather, *Hungry World*.

<sup>13</sup> Dietmar Rothermund, *An Economic History of India: From Pre-Colonial Times to 1986* (London, 1988), p. 141-147.

<sup>14</sup> Tirthankar Roy, "Roots of Agrarian Crisis in Interwar India: Retrieving a Narrative", *Economic and Political Weekly* (2006) **41**: 5389-5400.

<sup>15</sup> Parayil, "The green revolution in India".

<sup>16</sup> Francesca Bray, *The Rice Economies: Technology and Development in Asian Societies* (Berkeley, Ca, 1986).

cultivation was optimized and hard to improve, the slower growth in rice production in traditional areas and seasons from the 1960s onwards buttresses her focus on the challenges in modernizing rice cultivation.

### **Locating Agricultural Revolutions**

Official statistics on agricultural production in India have been compiled since 1891-92, though there are several issues with coverage of areas and methods of production and yield estimation. George Blyn's seminal work in correcting anomalies and filling gaps in the official data<sup>17</sup> are usually taken to constitute definitive statistics for the colonial period; his estimates of growth rates of area, production and yield of foodgrains are summarized in Table 1.1. As can be seen, the last six decades of colonial rule saw a significant decline in yields of foodgrains; mostly led by declining rice yields. The acreage under rice also grew slowly, making for an overall slow rate of growth of foodgrain production. Acreages and yields of wheat increased faster than that of foodgrains as a whole; though with both increasing at the rate of less than half percent, the performance of wheat production in India was far from stellar.

Some detailed analysis of the period from 1931 onwards is called for. The scenario of absolute decline in rice yields and (slowly) growing yield of wheat appears to have intensified by the 1930s; wheat yields rose 0.87% a year in that decade compared to the average of 0.38% for the whole period, while rice yields declined faster (1.51%) than they did for the period as a whole (0.24%). However, at least the intensification of the overall trend in yield growth appears to have abated in the decade ending with the war and Indian independence; rice yields declined at only 0.48% at a time when wheat yields too were declining at 0.2%. In the growth rate of acreage however, the general comparative trend between wheat and rice in the 1930s and 1940s was the reverse of the one for the period as a whole; the area under rice grew at a rate higher than that under wheat. This trend was stronger through the war as the decade ending in 1946 saw the rice acreage grow at 1.23% compared to just 0.29% in the case of wheat. The 1940s saw an impressive turnaround in the landscape of rice production; not only did acreage increase at a high rate, but the decline in yields also slowed down substantially. Rising war time prices of rice resulted in diverting of more (and better) land to rice cultivation; the Grow More Food scheme also clearly had some impact. In contrast, wheat yields declined during this last decade

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<sup>17</sup> Blyn, *Agricultural Trends*.

of colonialism (though still slower than rice) and the growth in the area under wheat slowed down.

Crop	Area (Percentage)			Yield (Percentage)			Production (Percentage)		
	1891-1946	1931-1941	1936-46	1891-1946	1931-1941	1936-46	1891-1946	1931-1941	1936-46
Rice	0.18	0.52	1.23	-0.24	-1.51	-0.48	-0.09	-1	0.76
Wheat	0.49	0.39	0.29	0.38	0.87	-0.2	0.84	1.38	0.08
Total Foodgrains	0.31	0.18	1.1	-0.18	-0.98	-0.47	0.11	-0.51	0.75

**Table 1.1: Annual growth rate of area, production and yield of foodgrains in India, 1891-1947.**

**Source:** Compiled from George Blyn, *Agricultural Trends in India, 1891-1947: Output, Availability and Productivity* (Philadelphia, Pa, 1966). Total Foodgrains includes Rice, Wheat, Jowar, Gram, Bajra, Barley, Maize and Ragi.

Thus independent India inherited a bleak (but improving) landscape of rice production and a better (but deteriorating) wheat production; making for an overall food production situation similar to that of rice. How did food production fare in the decades since? As the official statistics in Table 1.2 show, in the first decade of planned economic development in India (the 1950s) food production grew at over six times the highest rate achieved during the colonial period. While this spectacular production growth slowed down in the 1960s, it has been much higher than the colonial period throughout the postcolonial period. Yield growth in the 1950s too represented quite a leap from the negative growth rates seen before 1947.

Decade ending in the year	Area (Percentage)	Production (Percentage)	Yield (Percentage)
1960-61	1.7	4.9	3.1
1970-71	0.7	2.8	2.1
1980-81	0.2	1.8	1.6
1990-91	0.1	3.1	3.0
2000-01	-0.5	1.1	1.7

**Table 1.2: Annual growth rate of area, production and yield of foodgrains in India, 1950-51 to 2000-01.**

**Source:** Computed using Directorate of Economics and Statistics, *Estimates of Area, Production and Yield of Principal Crops in India* (New Delhi, 1951-2001).

Thus the decades of the 1960s and 1970s when a “Green Revolution” supposedly took place was actually a period of considerably slower growth within the postcolonial period. The growth rate of yield picked up during the 1980s, only to fall again in the 1990s, showing no clear long-term upwards trend (see Table 1.2) over the highs seen in the 1950s.

### **The particularity of wheat**

As the policy change and technology adoption that led to the Green Revolution are typically placed in the mid-1960s, it may be useful to do a detailed comparison of the postcolonial period of economic planning before and after 1965. The growth rate of food grain production between 1965 and 1979, during the Green Revolution was about 2.8%; this was lower than the remarkable 4.1% achieved during 1951-65. The growth rate of yield in the 1965-79 period, at 2.2% was also lower than the 2.7% achieved during 1951-65.<sup>18</sup> This general lowering of the rate of growth of yield is remarkable, considering the fact that this was a time when massive sums were spent on introducing modern inputs into Indian agriculture.

As for the growth in yields of individual crops, only in the case of wheat was the rate of growth of yield (at 3.9%) higher during the Green Revolution than the rate in the preceding period (2.3%). For rice (corresponding figures are 1.5% and 3.5% respectively) and other cereals (1.7% and 2.4%), the growth of yield declined during the Green Revolution.<sup>19</sup> Yields of pulses which grew at 1.2% before 1965 saw an absolute decline at the rate of 0.07% during the Green Revolution; this is significant as pulses are an important source of protein in the Indian diet and could not be easily imported as they were not a widely traded international commodity. More remarkable is the fact that very promising new seed varieties had been developed not just for wheat and rice but also for jowar, maize and bajra; the latter saw a yield growth rate of 5.9% (second only to wheat's 7.3%) in the period from 1965 to 1972.<sup>20</sup> This growth run, which was described by some as “one of the most outstanding plant breeding success stories of all time”<sup>21</sup> ended by the

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<sup>18</sup> From an analysis of Directorate of Economics and Statistics, *Estimates of Area, Production and Yield of Principal Crops in India* (New Delhi, 1955-1985).

<sup>19</sup> From an analysis of Directorate of Economics and Statistics, *Estimates of Area, Production and Yield of Principal Crops in India* (New Delhi, 1955-1985).

<sup>20</sup> V.S. Vyas, *India's High Yielding Varieties Programme in Wheat 1966-67 to 1971-72* (Mexico City, 1975).

<sup>21</sup> Glenn W. Burton and Jerrel B. Powell, “Pearl millet”, *Advances in Agronomy* 20.

mid-1970s and it was acknowledged that the growth could largely be ascribed to a long spell of good monsoon years.<sup>22</sup>

While the statistics underlying the above analysis continue to be widely published and used by the government, at some point it was felt that data collection practices had substantially underestimated production in the early 1950s; as a result a volume containing “adjusted estimates of production” was published in 1965 using some standard formulae for corrections. If production of the early 1950s had indeed been underestimated, it would imply that the actual growth in the pre-Green Revolution period was lower than suggested by the above analysis. Table 1.3 shows the statistical analysis conducted by others on the new data following the best recommended econometric practices; for example growth rates are only compared between particular “peak years” where there was no sharp production decline in years too close to either end point. The years ending 1966 and 1967 have been neglected as the production drop due to drought conditions was considered catastrophic enough to warp any analysis.<sup>23</sup>

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<sup>22</sup> N. S. Jodha, "Prospects for Coarse Cereals: Permanent Constraints of Jowar and Bajra", *Economic and Political Weekly* (1973) **8**: A145- A150.

<sup>23</sup> Sarma and Gandhi, *Production and Consumption*, p. 32.

Period	Rice (Percentage)	Wheat (Percentage)	Total foodgrains (Percentage)
<b>Area</b>			
1950-65	1.3	2.7	1.4
1968-76	0.7	3.2	0.4
1976-84	0.2	1.9	0.2
<b>Yield</b>			
1950-65	2.2	1.3	1.4
1968-76	1.2	2.2	1.5
1976-84	1.8	3.7	2.3
<b>Production</b>			
1950-65	3.5	4.0	2.8
1968-76	1.9	5.5	1.9
1976-84	2.0	5.7	2.5

**Table 1.3: Adjusted annual growth rate of area, production and yield of foodgrains in India, 1950-1984.**

**Source:** J. S. Sarma and Vasant P. Gandhi, *Production and Consumption of Foodgrains in India: Implications of Accelerated Economic Growth and Poverty Alleviation* (Washington, DC, 1990).

As can be seen, the growth rate of foodgrain production in the period 1950-65 has never been equalled since then. As for yields, there was a marginal increase (in no way suggesting a revolution) in the growth rate during the period 1968-76. There was indeed substantial growth in the period between 1976 and 1984, but none of these changes is comparable to the leap in the 1950s from the negative or negligible growth rates in the late colonial period. The transformation in the decade from the late 1970s was long after the policy change of the mid-1960s; this reflected the moderate success of the long “complicated business of development” which was precisely what Green Revolution policies were designed to avoid according to William Gaud, the USAID administrator who had coined the term.<sup>24</sup> In any case, the fragility of this statistical revolution is

<sup>24</sup> As quoted in Kusum Nair, *Land and Labor in Agriculture in Asia and Africa* (Riverdale, Md., 1983), p.67.

underlined by the fact that 1983-84 was a particularly good year; foodgrain production *fell* in subsequent years and would equal the 1983-84 figure only in 1988-89.<sup>25</sup>

Thus it is not surprising that despite the heralding of a Green Revolution, there continued to be great concern among economists whether India was finally on track to solve her production problems. In the late 1970s, TN Srinivasan wrote that “there is as yet no Green Revolution”<sup>26</sup> and A Vaidyanathan summarized the experience of the past decade,

Optimism may well have been justified a decade back. At that time, it seemed that given the abysmally low productivity and technological level of Indian agriculture, rapid growth should be relatively easy to achieve... The advent of the HYVs in the mid-sixties lent greater confidence to this view.

But the fact that after a decade of accelerated irrigation development, fertiliser use, and the rapid spread of HYVs, growth rates of production have not increased and may in fact have fallen compels a sober re-assessment... naive optimism of agricultural prospects in the face of such experience can only further compound these problems.<sup>27</sup>

The increase in the growth rate of yield was entirely confined to wheat. In the case of rice (India's main food crop) the growth rate of yield between 1950 and 1965 remained unparalleled. As late as the 1980s, there was considerable controversy over whether growth rates had declined.<sup>28</sup>

Thus when it comes to a possible Green Revolution in the 1960s and 1970s, we are left with the peculiar case of wheat. Indeed many Indians never took to the phrase Green Revolution, preferring to refer to a ‘wheat revolution’.<sup>29</sup> Wheat was India's third most important food crop (after rice and jowar) and contributed a mere 14% of India's

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<sup>25</sup> Computed using Directorate of Economics and Statistics, *Estimates of Area, Production and Yield of Principal Crops in India* (New Delhi, 1979-90).

<sup>26</sup> T.N. Srinivasan, “Trends in Agriculture in India, 1949-50-1977-78”, *Economic and Political Weekly* (1979) **14**: 1283.

<sup>27</sup> A Vaidyanathan, “Performance and Prospects of Crop Production in India”, *Economic and Political Weekly* (1977) **12**: 1355.

<sup>28</sup> Sarma and Vasant P. Gandhi, *Production and Consumption*, p. 83.

<sup>29</sup> See for example, T.N. Srinivasan, “The Green Revolution or Wheat Revolution”, in M.L. Dantwala (ed.), *Comparative Experience of Agricultural Development in Developing Countries of Asia and the Southeast since World War II* (Bombay, 1972), p. 407

foodgrain production on about 11% of India's foodgrain land in 1964-65. Of the entirely unremarkable increase in India's foodgrain production in the 14 years since then, wheat contributed nearly 55%, and wheat yields grew at a high rate of 3.8% during this period compared to only 2.3% in the preceding period.

**Wheat: The beginnings of revolutionary production**

Between 1961 and 1972, the production of wheat in India increased by 150% (see Table 1.4). This growth came from a 50% increase in the area under wheat and a 70% increase in the average yield; this is the production boom most identified with the Green Revolution.



	All of India				Punjab			
Year ending	Total area (mn ha)	Percentage of area irrigated	Production (mn ton)	Yield (ton/ha)	Total area (mn ha)	Percentage of area irrigated	Production (mn ton)	Yield (ton/ha)
'51	10.0	34	6.4	0.64	1.6	55	1.3	0.82
'56	12.7	33	8.6	0.68	2.0	52	1.8	0.91
'61	12.9	33	10.6	0.82	2.2	51	2.5	1.16
'64	13.5	35	9.9	0.73	2.4	56	2.8	1.20
'65	13.5	37	12.1	0.90	2.5	57	3.4	1.37
'66	12.5	43	10.4	0.83	2.4	64	2.8	1.17
'67	12.8	48	11.4	0.89	2.4	71	3.5	1.51
'68	14.9	43	16.5	1.11	2.6	67	4.8	1.83
'69	15.6	50	18.7	1.19	3.0	79	6.0	2.04
'70	16.8	51	20.1	1.20	3.2	82	6.9	2.17
'71	18.3	54	23.2	1.27	3.4	83	7.5	2.18
'72	19.1	54	26.5	1.39	3.5	86	8.0	2.28

**Table 1.4: Wheat Production in India, 1950-1972.**

**Source and Notes:** Compiled from Directorate of Economics and Statistics, *Indian Agricultural Statistics* (New Delhi, 1952-1975). Punjab figures for 1951 included PEPSU which was later merged into the state. The province was bifurcated into Punjab and Haryana in 1966, but all the figures in this table correspond to the undivided state.

Despite its low share of overall food production, wheat was important to food policy due to its disproportionate contribution to urban consumption and a demand which rose faster with incomes than that of coarse cereals like jowar. From the mid-1950s onwards, the government imported large quantities of wheat (equalling about a quarter of domestic production) mostly from the United States under the very favourable terms of the PL 480 programme. This enabled the government to create a “psychology of abundance” through cheap sales of imported stock without having to rely on local procurement.<sup>30</sup> Nevertheless, domestic wheat production too grew at nearly 4% from the early 1950s to the mid-1960s, higher than the 3.5% achieved by rice and the 2.8% achieved by foodgrains as a whole. This increase however came mostly from an expansion in the area under wheat rather than from growing yields; wheat yields grew at 1.3% during the period compared to rice which grew at 2.2%. Commentators often blamed the easy availability

<sup>30</sup> Nilakanth Rath and V.S. Patvardhan, *Impact of Assistance under PL 480 on Indian Economy* (Pune, India, 1967), p.2.

of wheat under the PL 480 programme for the lack of a strong domestic wheat production policy.<sup>31</sup>

In 1951, the use of fertilizers on the crop was fairly negligible; irrigation was perhaps the chief determinant of yields. A little over half the area under wheat was irrigated in Punjab, while the average for all of India was about a third; the average yield in Punjab was higher than the all India figure by nearly a third. Indeed in some good years in the 1950s, some districts of Punjab had yields over 5 times as high as dry districts in other parts of the country.<sup>32</sup> Revolutionary yields could clearly be achieved with just irrigation.

In light of the recommendations of the Ford Foundation's Report *India's Food Crisis and Steps to Meet It*,<sup>33</sup> in 1960, the Government of India started the Intensive Agricultural Development Programme (IADP) to improve agriculture using existing knowledge in areas selected for having assured water supply (from irrigation and rainfall) as well as an adequate agricultural extension service built up during a decade of community development. Of India's 315 districts, seven (one in each major agricultural state) were initially picked; two of these were important wheat producers.<sup>34</sup> As an area with already high yields which devoted a substantial share of its (mostly private well) irrigation to wheat, Ludhiana (Punjab) was perhaps a natural choice. The other was Aligarh (UP), which benefited from the Upper Ganges Canal, India's oldest public tubewell network, in addition to a growing number of private tubewells.

The IADP was to be based on a 10 point programme of credit, inputs of fertilizers, seeds & pesticides, assured prices, improved marketing, improved water & farm management, direct farm planning, village planning, analysis & evaluation and administrative changes. There were substantial deviations from this plan; two of which were significant. The idea of assured prices was given up on the grounds of high costs. Improvements in water management, particularly significant in the rice tracts, also proved hard to implement.

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<sup>31</sup> For an excellent contemporary analysis of the PL 480 programme, see Rath and Patvardhan, *Impact of Assistance*.

<sup>32</sup> See Directorate of Economics and Statistics, *Estimates of Area, Production and Yield of Principal Crops in India* (New Delhi, 1950-1960).

<sup>33</sup> Agricultural Production Team (Ford Foundation) and Ministry of Food and Agriculture, *Report on India's food crisis & steps to meet it* (New Delhi, 1959).

<sup>34</sup> Carl C. Malone and Sherman E. Johnson, "The Intensive Agricultural Development Program in India", *Agricultural Economics Research* (1971) **23**:25-35. Malone and Johnson were closely associated with the IADP.

The Irrigation Department disavowed all responsibility for infrastructure beyond outlets serving several farms, while efforts to stimulate “voluntary group action” in villages had “minimal effect” as technical skills were not available; thus Ford Foundation funds for the improving water management remained unutilized.<sup>35</sup>

In the wheat growing areas, the programme emphasized the expansion of acreage with “more local irrigation” referring to wells and tubewells; by 1966, 300,000 additional acres of wheatland were under irrigation in these districts. Increased fertilizer use was also important to this “production package”; indeed it was used an index of the adoption of the package. The fertilizer use per development block in the IADP wheat districts, which were about equal to their state averages in 1959-60 increased by 370% in 1963-64, as compared to the state average of 178%. These efforts, together with a 20% increase in the area under wheat led to a more than doubling of wheat production in the two districts by 1966; *before the advent of the higher yielding varieties* as a 1971 study authored by the IADP’s architects emphasized.<sup>36</sup>

### **Steamrolling the Mexican varieties**

The High Yielding Varieties (HYVs) being referred to were the dwarf varieties developed in Mexico in the early 1960s by Norman Borlaug of the Rockefeller Foundation using seed material from Japan. Samples of these were obtained by the Indian Agricultural Research Institute in Delhi in 1963. These were approved for cultivation in irrigated wheat lands in 1965, though they were not cultivated on any significant scale for food (rather than seed or demonstration) production before 1967-68 when about 18% of the wheat area was planted with them.<sup>37</sup>

The Agriculture Minister C. Subramaniam and his secretary B. Sivaraman give differing accounts of how the seeds were adopted and both accounts demonstrate that the decision was far from uncontroversial. According to Subramaniam, Dr. Ralph Cummings of the Rockefeller Foundation approached him in late 1964, complaining of resistance from Indian scientists in clearing the seeds for commercial cultivation despite spectacular yields achieved on research farms. Subramaniam called in a panel of scientists,

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<sup>35</sup> Dorris D. Brown, *Agricultural Development in India’s districts* (Cambridge, Ma, 1971). Brown was closely associated with the IADP.

<sup>36</sup> Malone and Johnson, “Intensive Agricultural Development Program”, p. 29.

<sup>37</sup> M.S. Swaminathan, “Foreword” in Khem Singh Gill, *Research on Dwarf Wheats* (New Delhi, 1979), pp. v-vi.

economists and administrators to discuss the problem over two or three days. Amongst the scientists, the seniors took a conservative view and argued that it was better to continue with the Indian breeding programme; while HYVs might have had heavy yields in controlled conditions, the “illiterate and tradition bound” Indian peasant would not take to the transformation of cultivation practices they demanded. Younger scientists however opined that “technology was bound to yield results”. Economists questioned the policy of concentrating all available fertilizer on the new seeds, arguing that production with so much fertilizer would be uneconomic.<sup>38</sup> In fact David Hopper, an influential Ford Foundation economist who attended these meetings went so far as to say that the scientists and the economists came to a “clear consensus” on prohibiting the use of the new seeds. But a small group who felt that “technological innovation” was the only hope managed to influence the politicians who decided to adopt the new seeds overriding all objections.<sup>39</sup>

According to Sivaraman, he learnt of the new seeds from the technical head of the seeds department in the agriculture ministry in June 1965 who showed him impressive results of trials conducted at two locations with the Mexican seeds; Sivaraman thus decided to push a food-production strategy centred on the new seeds. But as policy was being formulated later that year, he discovered that he had only been shown the results of two out of fourteen trials; in all the other trials, one or another local variety had performed better than the Mexican varieties. He ordered the Agricultural Commissioner to proceed at once to the twelve other stations, check if protocols had been followed and seize all records of the trials. Yet, even before a full enquiry could be made, Sivaraman appears to have made up his mind in favour of the dwarf varieties. He argued that prior experience had taught him that Indian research workers never kept to protocol. As the new varieties had not been developed in India, he felt that their poor performance in the trials was the result of an active lobby for varieties developed in India. He argued that as American experts had been monitoring the trials in the two locations where the Mexican seeds performed well, there could have been no fudging of results; thus trusting the integrity of American scientists over Indians.<sup>40</sup>

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<sup>38</sup> C. Subramaniam, *The New Strategy in Indian Agriculture: The First Decade and After* (New Delhi, 1979), pp. 30-33.

<sup>39</sup> W. David Hopper, “Distortion of Agricultural Development Resulting from Government Prohibitions”, in Theodore Schultz (ed.), *Distortions of Agricultural Incentives* (Bloomington, In, 1978), pp. 69-71.

<sup>40</sup> Sivaraman, *Bitter Sweet*, pp. 299-304.

The full data had also made its way to Dr. VKRV Rao, the Planning Commission member in charge of agriculture who then made grave accusations against Sivaraman and particular scientists, though his ability to create trouble was limited by his unwillingness to put the accusations in writing as Sivaraman demanded. But Rao continued to resist, delaying his approval of the programme for over a year before eventually resigning to contest elections in 1967. The programme however went ahead without his approval; as Sivaraman boasted, “it was steamrolled”.<sup>41</sup> Whatever the details of the particular events, this “steamrolling” has been seen as exemplar of not giving in to irrational fears about new technology; David Hopper later used the perceived success of the new varieties to argue for a limit to government prohibitions on technologies including DDT.<sup>42</sup>

### **High Yielding Varieties?**

The specific problem ostensibly addressed by the new dwarf plants was called lodging. While increased use of fertilizers was seen as important in increasing yields, traditional varieties of wheat were tall and had a weak, spindly stalk. Under heavy fertilizer dosages, these could not bear the increased weight of the ears and fell over and lodged, or fell over. Being short, and having a high grain to straw ratio, the dwarf varieties were resistant to lodging at much higher levels of fertilizer application.

But in addition to the much emphasized problem of lodging, a key parameter in the fertilizer-variety relationship was the additional yield that could be obtained from every pound of additional fertilizer. This was represented by a curve between yield and fertilizer application; the usual form was an inverted U-shaped curve with diminishing marginal returns with increasing fertilizer application. As the new seeds, together with greater availability of fertilizers were being publicized, two economists B. S. Minhas (a Stanford trained economist at the Indian Statistical Institute) and T. N. Srinivasan (a Yale trained economist also with the Indian Statistical Institute) used these curves to publicly question India’s fertilizer programme in early 1966.<sup>43</sup> The government had recommended a fertilizer dosage close to the limit of lodging for the dwarf varieties; any remaining fertilizer was to be spread thin at much lower dosages over the irrigated and unirrigated local varieties. According to Minhas and Srinivasan, the higher response of all varieties

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<sup>41</sup> Sivaraman, *Bitter Sweet*, p. 304.

<sup>42</sup> Hopper, “Distortion”, p. 71.

<sup>43</sup> B. S. Minhas and T. N. Srinivasan, “New Agricultural Strategy Analysed”, *Yojana* (1966) **10**: 20-24

to fertilizer at low dosages implied that greater production would result from the same amount of fertilizer if it was less concentrated on the dwarf varieties alone. Upto 50% higher total production could be achieved by reducing the dosage on the dwarf varieties to less than 50% of the government-recommended dose and using the fertilizer thus saved on tall wheat varieties. Substantial (though lesser) reductions in fertilizer dosages would also be called for if profitability to the HYV farmer, rather than total production were to be maximized. Ridiculing the aspirations of plant breeders such as Dr. M. S. Swaminathan who asserted that it was possible for India to produce 100 million tonnes of food grains on 25 million acres (compared to the then record of 77 million tonnes on 230 million acres), the article contended that even if such a miracle was possible, it was not economically sound. To them, the “enthusiasm of extremely high dosages” stemmed from a lack of appreciation of optimal allocation of resources.<sup>44</sup> While many might have questioned the policy of concentrating resources from the point of view of equity, Minhas and Srinivasan questioned it from the perspective of production, on the altar of which long standing ideas about equity were being ostensibly sacrificed.

To C. Subramaniam, this critique was “devastating”; he later wrote that the authors had been mistaken in assuming limited fertilizer availability without looking to the future when the same would be plentiful.<sup>45</sup> Sivaraman wanted to issue an official rejoinder and turned to the Ford Foundation’s David Hopper, who advised him to do nothing; according to him, people in India had too much time for arguments.<sup>46</sup> The lack of a response was of course because the argument was sound; fertilizer would be a precious commodity for several years in India, because of low domestic production in the 1960s and the oil shocks of the 1970s. It was only in 1968, the year of the bumper harvest that three Rockefeller Foundation economists were confident enough to publish a paper arguing that the article had been based on outdated data; more recent trials supported the policy of concentration. While Minhas and Srinivasan had questioned only fertilizer allocation and not the dwarf varieties themselves, the response felt the need to add that in any case, there was no

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<sup>44</sup> Minhas and Srinivasan, “New Agricultural Strategy”, p. 20.

<sup>45</sup> Subramaniam, *New Strategy*, p. 81.

<sup>46</sup> Sivaraman, *Bitter Sweet*, p. 304.

necessity to rely on data; the overwhelming acceptance of short varieties by cultivators was ample testimony to their superiority.<sup>47</sup>

The reason Minhas and Srinivasan did not question the dwarf plants themselves had to do with the published data available to them. The undefined “irrigated local” wheat variety was assumed to yield 1 ton per hectare with no fertilizer, as compared to 1.65 tonnes in the case of the dwarfs; hence they recommended that even with no fertilizer, as long as enough dwarf seeds were available, it made sense to plant the entire irrigated wheat acreage with the new seeds. But the former was an unreasonably low number; irrigated districts in Punjab growing locally improved varieties sometimes exceeded the figure in the 1950s. Comparisons published later referred to specific locally developed varieties, most notably C-306 which was approved for cultivation in 1965, the same year as the dwarf wheats. C-306 was developed by Ram Dhan Singh who had trained under Sir Albert Howard, the father of wheat research in India. Initial comparison in 1964-65 only appears to have been conducted at a high 80 kg of nitrogen per hectare; even so, in Ludhiana it yielded 3997 kg/ ha, coming in second amongst the five varieties tested, only surpassed by Lerma Rojo 64 at 4598 kg/ha; other dwarf varieties performed poorly.<sup>48</sup> Indeed, C 306 was classified as a HYV and included within statistics for the same until 1970;<sup>49</sup> it was later recommended only for unirrigated conditions.<sup>50</sup>

Between 1966 and 1969, trials were conducted in India with varying fertilizer dosages. These showed that with no fertilizer applied, the tall varieties did better than the dwarfs. At low dosages, they produced higher yields than dwarf varieties; an advantage they lost somewhere between 40 and 80 kg of nitrogen per hectare. Yet, even at the very high level of 200 kg of nitrogen/ ha, their yield was only 20% lower than the best dwarf varieties. (See Table 1.5).

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<sup>47</sup> Ralph W. Cummings, Jr., Robert W. Herdt and S. K. Ray, "New Agricultural Strategy Revisited", *Economic and Political Weekly* (1968) 3(43):A15 -A23.

<sup>48</sup> Gill, *Research*, p.84.

<sup>49</sup> Vyas, *India's High Yielding Varieties Programme*, p.39.

<sup>50</sup> Gill, *Research*, p. 132.

Nitrogen (kg/ha)	Tall varieties (9 trials), yield (kg/ha)	Mean red dwarfs Sonora 64 and Lerma Rojo 64 (30 trials, yield (kg/ha)	Mean amber dwarfs Sonalika, Sharbita Sonora, Kalyan Sona, S 331 69 trials), yield (kg/ha)
0	2100	1800	1920
40	3180	3060	2980
80	3550	3760	3850
120	3600	4190	4180
160	3650	4150	4430
200	3510	4180	4400

**Table 1.5: Response of wheat varieties to fertilizer application.**

**Source:** As quoted in K.S. Gill, *Research on dwarf wheats* (New Delhi, 1979), p. 88.

Such was the faith in the new seeds that the efficient fertilizer use of tall varieties has largely gone unnoticed. Even critics who termed the new seeds were not high *yielding* varieties, merely high response varieties did not mention the fact that there was such a thing as the former and those were the Indian tall wheats.<sup>51</sup> This carelessness made for a general idea that fertilizers and HYVs were complementary technologies in every way. When a study in the 1970s found that the efficiency of Indian foodgrain production in using inputs (land, irrigation and fertilizer) had decreased drastically in the period between 1960 and 1974 as compared to the 1950s, the author found it baffling that the same had occurred during a period which saw the rise of HYVs which were ostensibly well suited to fertilized agriculture.<sup>52</sup> Of course it was true that even with traditional varieties, efficiency of resource use would have decreased with the increasing quantity of inputs. When another economist referred to the better yields of tall varieties at low dosages than HYVs and sought to challenge the same,<sup>53</sup> the economist community was astounded. Such was the faith in HYVs that one respondent claimed that he knew of no scientist or economist who assumed that tall varieties had better yields at low dosages than HYVs; thus the very premise of the original paper was flawed.<sup>54</sup> Thus it came to be

<sup>51</sup> See for example Ramachandra Guha and Joan Martinez Alier, *Varieties of Environmentalism: Essays North and South* (London, 1997), p. 111.

<sup>52</sup> A. Vaidyanathan, "Performance".

<sup>53</sup> Kirit S. Parikh, "HYV Fertilisers: Synergy or Substitution: Implications for Policy and Prospects for Agricultural Development", *Economic and Political Weekly* (1978) **13**: A2-A8.

<sup>54</sup> A. Vaidyanathan, "HYV and Fertilisers: Synergy or Substitution?: A Comment", *Economic and Political Weekly* (1978) **13**: 1031-1035.



believed that HYVs were miracle seeds, more efficient than conventional varieties, a belief which has remained central to accounts of the Green Revolution.

The higher yields of tall varieties at lower fertilizer doses strongly suggests that the transformation of wheat production could have been achieved (and more cheaply) without the dwarf varieties altogether. This could have been done by spreading the fertilizer thin on tall Indian varieties in irrigated land across India, rather than just on dwarf varieties in some areas. While a statistical picture of fertilizer use in the 1960s in India is not available, it is unlikely that even a significant proportion of farmers in Punjab's most advanced districts were facing the problem of lodging. Before the dwarf varieties were released, the Ford Foundation estimated that fertilizer sales in Ludhiana had barely attained a third of their potential, and surveys found that only 3% of irrigated farms used the recommended fertilizer dose, and the average dose was only 36% of the recommendation.<sup>55</sup> After the HYVs were released, with 86% of its land irrigated in 1972 the average yield in Punjab was 2.28 t/ha; barely higher than what could have been achieved with tall varieties and no fertilizer whatsoever. Even Ludhiana, the most progressive of wheat districts only achieved an average of 3245 kg/ha by the mid-1970s; it is unlikely that lodging was a real problem for the overwhelming majority of its cultivators in the mid-1960s. Indeed, a chief complaint of all studies of the Green Revolution was that the Indian peasant did not apply anywhere close to the recommended dose of fertilizers on the dwarf plants.<sup>56</sup>

Thus the growth of wheat yields in the late 1960s and the 1970s did not require dwarf wheat varieties and their adoption made for very inefficient fertilizer use. But it is indeed possible that they were a crucial technology later as a larger proportion of farmers began to use high fertilizer dosages. Thus a study found that for all food crops in Asia as a whole, "modern varieties" contributed barely a fifth of the yield growth during the "Early Green Revolution" from 1961-1980, though they contributed nearly half of the (slower) yield growth during the "Late Green Revolution" from 1981-2000; in the developing world as a whole, modern varieties' contribution to yield before 1980 was even lower. "Other

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<sup>55</sup> As quoted in C. A. Robertson, G. R. Saini and R. K. Sharma, "The Package Programme: an Appraisal", *Economic and Political Weekly* (1966) 1:79-85.

<sup>56</sup> Even Sivaraman had to lament this, see B. Sivaraman, "Scientific Agriculture is Neutral to Scale: The Fallacy and the Remedy", *Journal of the Indian Society of Agricultural Statistics* (1973) 25: 75-90 initially delivered as the Rajendra Prasad Memorial Lecture at Kalyani University on 27<sup>th</sup> December 1972.

inputs” accounted for the lion’s share of yield increases throughout the period from 1961 onwards all over the developing world.<sup>57</sup>

### **Irrigation and the Wheat Revolution**

Stretching at least as far back to early colonial India, irrigation was seen as of prime importance in increasing agricultural production; this was both through increased yields and the ability to grow crops which would be impossible without irrigation. The standard yardstick (criticized as too conservative by many) for increased production from irrigation used since the Grow More Food campaign during the Second World War was half a ton per hectare.<sup>58</sup> By that yardstick, wheat production in large parts of India could be doubled just with irrigation. But both in Punjab and India as a whole, the rate of growth of irrigated wheatland in the 1950s was less than the rate of growth of the wheat area as a whole; the proportion of wheatland irrigated remained at about a third in the country during the decade. This, together with the general lack of technology change in wheat cultivation was blamed on the lack of incentive as prices had been actively kept low using PL 480 supplies.<sup>59</sup>

The trend reversed in the next decade, with the annual growth rate of the area of wheat irrigated in Punjab achieving a high of nearly 38% between in 1968-69. The state went from irrigating half its wheat land in 1961 to irrigating 86% in 1972. India as a whole went from irrigating a third of its wheat land to well over half. In fact, the country went from dedicating barely an unchanged seventh (15.1%) of its irrigated area to wheat in 1961 to over a quarter (26%) in 1971 and nearly a third (31.2%) in 1977; reflecting the increased concentration of national resources on what was initially a minor crop. In relative terms, rice, the most widespread food crop saw a decline in its share of the national irrigated area from 44.7% in 1961 to 33.9% in 1977.<sup>60</sup>

On its own, this spectacular growth in irrigation was at least as important to the yield revolution as fertilizers. In addition, it provided the base for fertilizer use (as money was seldom risked on fertilizers for rainfed fields) and enabled the application of the latter

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<sup>57</sup> R. E. Evenson and D. Gollin, "Assessing the Impact of the Green Revolution, 1960 to 2000", *Science* (2003) **300**:760

<sup>58</sup> As quoted in A. Vaidyanathan, "Performance", p. 1356.

<sup>59</sup> Rath and Patvardhan, *Impact of Assistance*, p.57.

<sup>60</sup> Figures taken from Ministry of Agriculture, *Indian Agriculture in Brief* (New Delhi, 1985).

over a wider area. Finally, besides protecting crop from drought, irrigation also facilitated a shift from lower yielding crops such as millets to higher yielding crops such as wheat. All these aspects together made for a huge impact on yields; for example in 1983-84 (a good monsoon year when such differentials are expected to be smaller than usual) foodgrain yields on irrigated land were on an average 2.3 times the yields on unirrigated land with the effect being most significant in low rainfall states such as Punjab and Haryana where wheat was dominant.<sup>61</sup>

The importance of irrigation was widely acknowledged by all actors; in a parliamentary speech in 1966, the minister C. Subramaniam said that while he was emphasizing the new seeds and fertilizers, water was necessary to push through the programme; without it one could not “just throw the seeds and fertilizer and ask the farmer to produce”.<sup>62</sup> Sivaraman went further and in a lecture to young civil servants in 1970, he said that the New Agricultural Strategy was “based on irrigation” and only later mentioned fertilizers and seeds.<sup>63</sup>

Though the new seed varieties were developed in Mexico primarily to enable higher fertilizer use, irrigation had played some role in thinking about the lodging problem in India. Most of India’s wheat production is spring wheat. In Europe, these short duration crops are sown in April or May and harvested in August or September. In India however, these were sown in October-November and harvested in March-April. High temperatures in March would subject the plant to intense atmospheric and soil drought, necessitating irrigation for optimum yields. This would however result in lodging, which could also happen due to rain, hailstorms and wind in late March, resulting in production instability. According to the scientist Dr. M.S. Swaminathan, together with fertilizers and disease resistance, this was at the centre of his study of Indian yield stagnation in 1962.<sup>64</sup> From the plant breeders’ perspective, dwarf varieties enabled *protective* irrigation. Unlike

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<sup>61</sup> B.D. Dhawan, *Irrigation in India’s Agricultural Development: Productivity, Stability and Equity* (New Delhi, 1988).

<sup>62</sup> As quoted in C. Subramaniam, *Hand of Destiny*, p. 225.

<sup>63</sup> B. Sivaraman, *Address by Shri B. Sivaraman on Collector's Role in Indian Agriculture at the National Academy of Administration, Mussoorie, on 14th May, 1970* (New Delhi, 1970), p. 13.

<sup>64</sup> M. S. Swaminathan, "Scientific Implications of HYV Programme", *Economic and Political Weekly* (1969) 4: 67-75.

fertilizers, there's no suggestion that water was seen as a *productive* input which the plant would use in heavy quantities to produce high yields.

It is a commonplace in economic literature of recent years that much of the HYV irrigation boom in the 1960s came from tubewells,<sup>65</sup> and private tubewells quickly became seen as a crucial. There were various reasons for this. The most important was that irrigation in itself led to higher production and tubewells were a quick way of extending irrigation. For reasons I will discuss in subsequent chapters, private tubewells were being privileged by policy in the mid-1960s; incentive prices were also offered for wheat which made for a quick payback of private investment on tubewell. The precise extent to which the new wheat irrigation came from tubewells is hard to estimate, as we only have statistics for source-wise irrigation for the total net irrigated area, rather than for each crop. In Punjab as a whole, the net increase in the groundwater-irrigated area between 1965-66 and 1971-72, even if entirely devoted to wheat could account for less than two thirds of the increase in irrigated wheatland between 1965-66 and 1971-72. Canals contributed significantly to the increase in irrigation of wheat as demonstrated by the case of districts such as Hissar (in Haryana which was carved out of Punjab in 1966) where there was practically no tubewell irrigation but the area of wheatland irrigated nearly doubled between 1966 and 1972 to contribute a fifth of Haryana's irrigated wheatland.<sup>66</sup>

### **Challenges of adapting to tradition, irrigation and monsoons: The “Unrevolutionary” case of rice**

Unlike wheat, there were no spectacular gains in the yield or production of rice, India's major food crop in the late 1960s (See Table 1.6). A doubling of production over 1960-61 levels would not take place until 1988-89 and average yields only doubled by the late 1990s. Production and yields in 1967-68 were about 20% higher than the previous two drought years but still lower than the 1964-65 high. The rate of growth of production of and yield of rice was lower in the period 1967-1979 than it had been in 1952-1965 despite the adoption of HYVs, in sharp contrast to experience of wheat as the official *Economic*

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<sup>65</sup> See the burgeoning economic literature on tubewells, especially Tushaar Shah, *Taming the Anarchy: Groundwater Governance in South Asia* (Washington, DC, 2009).

<sup>66</sup> Computed from Directorate of Economics and Statistics, *Indian Agricultural Statistics* (1967-74).

*Survey of India* (ESI) for the year 1979-80 noted.<sup>67</sup> Even as some had proclaimed a Green Revolution in rice in the late 1960s, as late as 1978, the *ESI* merely noted that it appeared that rice production was tending to stabilize at a disappointing level of six to eight million tonnes higher than early 1960s levels, though it was “too early to make a firm assertion”.<sup>68</sup> That caution was well founded, for soon, the 1979-80 drought led to a 21% decline in rice production. This indicates the importance of irrigation; the percentage of the rice crop irrigated had barely grown in the 1960s and 1970s (See Table 1.6).

Year	Area(mn ha)	Production (mn tons)	Yield (kg/ ha)	Area Under Irrigation (Percentage)
1950-51	30.81	20.58	668	31.7
1955-56	31.52	27.56	874.4	34.9
1960-61	34.13	34.58	1013.2	36.8
1963-64	35.81	37	1033.2	37.1
1964-65	36.46	39.31	1078.2	37.3
1965-66	35.47	30.59	862.4	36.5
1966-67	35.25	30.44	863	37.9
1967-68	36.44	37.61	1032.1	38.6
1971-72	37.76	43.07	1140.6	37.2
1972-73	36.69	39.24	1069.5	39.1
1978-79	40.48	53.77	1328.3	41.6
1979-80	39.42	42.33	1073.8	42.8
1983-84	41.24	60.1	1457.3	42.7
1988-89	41.73	70.49	1689.2	45.8
1999-00	45.16	89.68	1986	53.9

**Table 1.6: Rice production in India, selected years.**

**Source:** Directorate of Economics and Statistics, *Area Production and Yield of Principal Crops in India* (New Delhi, 1950-2001) for various years.

The seemingly slow growth in yields was in part due to past good performance of the previous period when much of the low hanging fruit had been exploited; rice had led the exceptional yield growth of the 1950s. Government efforts at propagating generally improved cultivation had focussed on rice, and the rice districts also used a larger amount of fertilizers. It is likely that the most advanced irrigated rice districts of southern India

<sup>67</sup> Ministry of Finance, *Economic Survey of India for 1979-80* (New Delhi, 1980).

Accessed online at <http://indiabudget.nic.in/es1979-80/2%20Agricultural%20Production.pdf> on 10<sup>th</sup> August 2015.

<sup>68</sup> Ministry of Finance, *Economic Survey for 1978-79* (New Delhi, 1980). Accessed online at <http://indiabudget.nic.in/es1978-79/2%20Agriculture.pdf> on 10<sup>th</sup> August 2015.

might have indeed been approaching levels of fertilizer use which made for declining returns; the same Ford Foundation study which noted low fertilizer use on wheat in Ludhiana noted that fertilizer sales in the well-irrigated West Godavari district (Andhra Pradesh) had already attained 105% of the potential, though this was quite an exceptional case.<sup>69</sup>

Attempts at improving rice cultivation made in the 1960s made painfully slow progress, and the centrality of irrigation reform as the solution to the problems of rice was unchallenged. As Subramaniam recalled, the changes in watering patterns required were more significant for rice than they were for wheat, terming this problem a completely new area in India which called for much study.<sup>70</sup> Water conveyance in rice tracts was not through individual field channels but relied on flooding from field to field; irrigation to a particular field could thus not be individually controlled. In addition, fertilizer applied to one field would wash into others thus making the system uncondusive to the individualistic application of fertilizer by a small number of farmers. Subramaniam noted that during a drought year in Thanjavur, the irrigation reservoirs ran dry and water was supplied only once a week; yields were strangely the best that year. Experts felt that the cracking of the soil after a good wetting aired the roots, but Thanjavur traditionalists “would not listen”. Traditionalists also believed that having at least 150 mm of standing water on the crop helped controlled weeds; to Subramaniam, this was a lazy way of weed control and he argued that the experiment had established that better water management could improve the yields of even traditional varieties.<sup>71</sup> More generally, Subramaniam felt that the most important obstacle to implementation of the new programme was a conflict between the Irrigation and Agriculture Departments. The latter had a rigid schedule for releasing water which they regarded “as the Bible” and would not budge from; their attitude was that “agriculture existed for irrigation and not the other way round.”<sup>72</sup>

While critiquing irrigation practices was an easy way for the Agriculture Minister to shift the blame to Irrigation Departments and to tradition, at least in the case of the rice HYVs, there appears to have been a grave mismatch between the needs of the seeds on one hand

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<sup>69</sup> As quoted in Robertson *et. al*, “The Package Programme”, p. 84.

<sup>70</sup> Subramaniam, *Hand of Destiny*, p. 203.

<sup>71</sup> Subramaniam, *Hand of Destiny*, p. 148.

<sup>72</sup> C Subramaniam, *Hand of Destiny*, p. 203.

and irrigation and monsoon schedules; Francine Frankel, a young political scientist commissioned by USAID to study the Green Revolution in 1969 has extensively documented the same. Unlike the dry growing season for wheat in India, rice cultivation traditionally engaged with the monsoon; this was one reason local varieties were very well suited to any given climate. In the West Godavary district for example, over half the land was irrigated from canals since the middle of the nineteenth century. Normally, cultivators planted paddy in June with the arrival of the south west monsoon, transplanted in mid-July and harvested in December after the retreat of the northeast monsoon. Being long duration and sensitive to the length of the day (a feature called *photo-period sensitivity*), varieties local to the area flowered when the length of the day reached a critical number of minutes; thenceforth maturity arrived at a fixed time after an interval sufficient for the retreat of the monsoon, so the rice could be harvested under sunny skies.<sup>73</sup>

But the much heralded technical breakthroughs achieved by the IR-8 rice strain developed in the Philippines were precisely the opposite: they were short duration and insensitive to photoperiod. If planted in June, the HYVs would mature by October; the harvest thus had to take place in heavy rains, leading to crop losses. It was the dry early summer, from the end of January to late April or May which was most suited for these varieties. One option was growing the IR-8 as a second crop during this period; but this was constrained by unpredictability in the irrigation of the first crop which made for delays in harvesting. Thus even as designed, the canal system was not suited for a break from the monsoon pattern, and they did not work well as designed; while cultivators were supposed to receive the first watering by June 1st, they were fortunate if it came in by June 15<sup>th</sup>. Those at the tail end of the supply channel had to wait an additional month. This prolonged the period of the first crop well into December, reducing the possibilities of a second crop. In any case irrigation was insufficient during the period of the second crop; the systems supplied water only with the onset of the monsoon and the supply, inadequate as it was even when available, lasted only until mid-March. Efforts to change cultivation cycles resulted in little more than devastating pest attacks.<sup>74</sup>

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<sup>73</sup> Francine Frankel, *India's Green Revolution: Economic Gains and Political Costs* (Princeton, NJ, 1971), pp. 121-129.

<sup>74</sup> Frankel, *India's Green Revolution*, pp. 121-129.

Similarly, Thanjavur, the rice bowl of Tamil Nadu, was irrigated by the Cauvery both from an ancient delta system and by the Mettur dam. But as Frankel put it, “the irrigation position was less favourable than first appeared”.<sup>75</sup> The canal system depended for supplies on rainfall; this often led to delays in releasing water from Mettur. The uncertain water situation limited double cropping to low lying land close to the canal outlets. Monsoon delays pushed harvesting well into October, leading to serious crop damage from rains. In addition, this delay led to a delay in planting the second crop which would then face acute water shortages from February. According to Frankel, one reason why the HYV programme was more successful in Thanjavur than in other places was that unlike IR 8, the locally developed ADT 27 seed used in Thanjavur had a high resistance to lodging in rains but the gains in this most advanced rice district were still decidedly limited.<sup>76</sup>

### **Tubewells and Rice: Revolution as a process of slow change**

To Frankel, groundwater irrigation could be the solution for the problems of the rice districts. While ADT 27’s prime success was its ability to be successfully cultivated on land that did not absolutely require tubewells (or borewells as the local system was called), only a cultivator with a tubewell could achieve optimum yields. Tubewells offered many advantages, such as not having to wait for the release of water from Mettur before sowing, and the protection of yields from water shortages during key stages of the growth cycle. Tubewells could also better ensure a second crop enabling agricultural diversification. Similarly in West Godavari, the problem could be solved with the use of a filter point, as a version of the tubewell was known in southern India. This would enable a crop to be planted by early May, transplanted by mid-June and harvested by mid-November leaving enough time for a second crop of HYV seeds. Water shortages towards to end of the season could also be made up with a tubewell, which could enable double and even triple cropping.<sup>77</sup>

But as Frankel noted, the vast majority of Thanjavur’s small farmers did not have the resources to tap groundwater aquifers and were reluctant to risk high expenditures on fertilizers as long as water control was uncertain; the largest gainers were big farmers

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<sup>75</sup> Francine Frankel, *India’s Green Revolution*, p. 143.

<sup>76</sup> Francine Frankel, *India’s Green Revolution*, pp. 143-151.

<sup>77</sup> Frankel, *India’s Green Revolution*, pp. 130-162.



with the ability to invest in filter points or in borewells.<sup>78</sup> In West Godavari, at the time of Frankel's writing in 1969, loan policies had been liberalized and nearly 66,000 acres were irrigated in the district by groundwater. However, the vast majority of cultivators who had less than the 5 acres required to afford a tubewell had been excluded, not just from the HYVs but also from the general gains in output that came with assured irrigation water: more efficient use of modern inputs, intensive cropping and diversification. In pockets where these constraints had been overcome, even small farmers made impressive gains.<sup>79</sup>

But overall, the gains were small, for the special conditions which enabled the wheat boom in Punjab were simply not replicable. These included tenurial conditions: a significant proportion of cultivators in Punjab were peasant proprietors with moderate sized holdings who had benefited from an aggressive policy of land consolidation and reform in the 1950s; this made for a significant number of holdings where investment in tubewells was viable. In fact, Charan Singh, the UP peasant leader (and briefly Prime Minister in 1979) retrospectively took credit for the Green Revolution and justified the much critiqued limitedness of the land reform he carried out in a previous capacity, quoting World Bank land reform expert Wolf Ladejinsky who commented that the process in western UP and Punjab had resulted in farm sizes optimal for tubewell investment.<sup>80</sup> Groundwater was plentifully and widely available at a depth relatively inexpensive to pump from and a soft strata which was cheap to drill through. Perhaps because India's rice imports had traditionally been negligible, the commodity had simply not been bestowed with the sense of national priority that wheat was; at least initially, "incentive prices" were low and there is much evidence that HYV paddy cultivation was simply not profitable enough to make the switch<sup>81</sup> and invest in tubewells.

But while scholars concentrated on the reasons for non-adoption of HYVs in the rice-growing areas in the 1970s, a small breakthrough in rice production was being achieved elsewhere. The northwestern plains comprising Punjab, Haryana and western Uttar

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<sup>78</sup> Frankel, *India's Green Revolution*, p. 154-156.

<sup>79</sup> Frankel, *India's Green Revolution*, p. 136.

<sup>80</sup> Charan Singh, *Economic Nightmares of India: Its Cause and Cure* (New Delhi, 1981), p. 121.

<sup>81</sup> See for example, Amal Krishna Dey, "Green Revolution Contrasts: Rice and Wheat", *Economic and Political Weekly* (1977) 12:921-925 and Shyamal Roy, "Profitability of HYV Paddy Cultivation", *Economic and Political Weekly* (1971) 6:A75-A78.

Pradesh had never been known for rice cultivation. Unlike Eastern India, the rainfall (and canal supplies) was inadequate for rice cultivation; and rice was hardly consumed, unlike southern India where it was an important cereal justifying irrigation. But during the late 1960s, changes in cropping pattern took place. Initially, during the tubewell boom between 1966 and 1972 the intensity of irrigation use actually fell drastically in Punjab's groundwater-irrigated districts such as Ludhiana, as farmers apparently focussed on the dry season winter wheat crop and apparently stopped irrigating less profitable crops during the monsoon.<sup>82</sup> But through the 1970s, Punjab's farmers, who had installed tubewells in response to price incentives for wheat, consolidated their gains by using those tubewells to irrigate rice during the inadequate monsoon. With limited rainfall and the controlled application of water enabled by tubewells, Punjab's farmers were free of the constraints that prevented high yields of monsoon rice in traditional rice-growing areas.

The state of Punjab went from producing barely 0.7% of India's rice in 1960-61 to 1.7% in 1970-71 and 7.18% in 1979-80. Figures for Haryana and western UP were less spectacular but still impressive. Punjab had already achieved an average yield of 3000 kg/ ha in 1977-78 (compared to the all India monsoon average of 1274 kg/ha); beyond that point, production in Punjab increased mostly due to expansion of the area under rice rather than increase in yields, as the all India average yield narrowed the gap by attaining about 1800 kg/ha in 1999-2000. The wheat-paddy cycle became the dominant cropping pattern in Punjab over the next couple of decades and the state contributed nearly 10% of India's rice production in 1999-2000, even though production in traditional rice areas had begun to pick up in the 1980s.<sup>83</sup> In the space of a decade, rice had gone from "zero to hero" in the Punjab.<sup>84</sup> The wheat-paddy cycle became central to the Punjabi economy as it continues to be today, sharing much of the blame for the environmental and economic crises of agriculture in the state.

The extent to which the rice boom in northwestern India was the result of active policy is unknown; but there was indeed a state stimulus. Punjab's farmers, having no home

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<sup>82</sup> From analysis of *All India Agricultural Statistics* for various years.

<sup>83</sup> From an analysis of statistics available on the Directorate of Rice Development's website <http://drd.dacnet.nic.in/> accessed online on 10<sup>th</sup> August 2015.

<sup>84</sup> Karam Singh and Sajla Kalra, "Rice Production in Punjab: Systems, Varietal Diversity, Growth and Sustainability", *Economic and Political Weekly* (2002) 37:3139.

market, produced rice largely for a monopoly buyer, the Food Corporation of India, a public sector company whose activities I shall detail in a subsequent chapter. With the proportion of its rice production procured by the government varying between 75% and 84% in the 1980s (for comparison, figures for traditional rice-producing states rarely ever touched the double digits), Punjab was the top ranking state in contributing rice to government stocks since at least the early 1970s, as it continues to be today.<sup>85</sup> Thus the boom in Punjabi rice cultivation had a disproportionately significant impact on India's food economy.

Outside the northwestern plains, the growth in yields of monsoon rice was slow in the 1970s; according to the *Economic Survey* for 1980-81, productivity gains had been confined to this region as the problems of water management and excessive moisture in other areas proved intractable.<sup>86</sup> In the quarter century from 1974, the production of monsoon rice in Punjab increased by over six times and in Haryana by five times; in none of the traditional areas did monsoon rice production even double.<sup>87</sup>

But extension to Punjab was not the only means of break away from the constraints of interplay between heavy monsoons and traditional rice cultivation. Besides noting that much of the increased rice production came from Punjab, another trend noted by the *Economic Survey* in the 1970s was that a "steadier element" was being provided to the growth in rice production by the increase in the cultivation of summer rice.<sup>88</sup> As reflected in recent statistic collection practices, rice in India really consists of five crops; autumn, winter, summer, *kharif* and *rabi*. While the old statistics referred to autumn, winter and summer, the Directorate of Rice Development has conveniently divided rice production into "*kharif*" (monsoon) and "*rabi* & summer" (non-monsoon) crops. Summer rice, entirely outside the influence of the monsoon contributed a negligible share of India's production before the 1970s. As it was usually grown exclusively under irrigation, water

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<sup>85</sup> On procurement, see P. S. George, *Some Aspects of Procurement and Distribution of Foodgrains in India* (Washington, DC, 1985).

<sup>86</sup> Ministry of Finance, *Economic Survey of India for 1980-81* (New Delhi, 1981). Accessed online at <http://indiabudget.nic.in/es1980-81/2%20Agricultural%20Production.pdf> on 10<sup>th</sup> August 2015.

<sup>87</sup> From an analysis of statistics available on the Directorate of Rice Development's website <http://drd.dacnet.nic.in/> accessed online on 10<sup>th</sup> August 2015.

<sup>88</sup> Ministry of Finance, *Economic Survey of India for 1977-78* (New Delhi, 1978). Accessed online at <http://indiabudget.nic.in/es1977-78/8%20Problems%20and%20Prospects.pdf> on 10<sup>th</sup> August 2015.

management was easy with no monsoon to deal with; summer rice always had high yields. The cultivation of summer rice took off in some parts of Eastern India in the 1980s and 1990s, concurrent with the Special Rice Production Programme and Special Foodgrains Production Programme which targeted selected blocks (subdivision of a district) with intensive development efforts.<sup>89</sup> The growth in the cultivation of summer rice was closely associated with a small tubewell boom in Eastern India during the period. In West Bengal, on a quarter of the land, *boro* rice contributed a third of the production that enabled the state to become the country's leading rice producer by 1999-2000. In a pattern similar to the contrast of production and yield growth in monsoon rice cultivation between Punjab and the rest of India, average yields of *boro* rice had increased to 3031 kg/ha by 1986-87 (compared to 1364 kg/ha for monsoon rice) and did not increase significantly beyond that point. In the subsequent decade, the area under *boro* rice increased, while the yields of *kharif* or monsoon rice played catch up, increasing yields to nearly 2000 kg/ha.<sup>90</sup> This revolution is far from complete as the Government of India seeks to increase tubewell irrigation in this groundwater rich but economically poor region as part of the "Bringing the Green Revolution to Eastern India" programme, even as it is desperately engaged in discouraging tubewells through crop diversification in the "original Green Revolution states".<sup>91</sup>

Of the 50 million tonne increase in rice production in the quarter century after 1974, a fifth has come with the expansion of monsoon cultivation in Punjab and Haryana (which account for 8% of the area planted with rice in India; the likely equally significant contribution of Western UP on the same lines has not been taken into account as the rest of the state cultivates monsoon rice in a traditional fashion) and another fifth has come from *rabi* & summer cultivation (on 10% of the area).<sup>92</sup> The specificities of tubewell irrigation played a much larger role in the seemingly less spectacular rice revolution than it did with wheat, where irrigation more generally (which happened to be from tubewells) was the important driver of yields. For this drastic seasonal and spatial shift in India's

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<sup>89</sup> Anon., *Rice in India: A Status Paper*. Accessed online at the Directorate of Rice Development's website.

<sup>90</sup> From an analysis of statistics available on the Directorate of Rice Development's website.

<sup>91</sup> Shobha Roy, "Tapping the East to Spread Green Revolution", *The Hindu Businessline* dated 28<sup>th</sup> February 2013.

<sup>92</sup> From an analysis of statistics available on the Directorate of Rice Development's website.

rice production landscape could only have been orchestrated through the decisive break in water management practices which tubewells were uniquely positioned to offer.

HYVs also played perhaps a larger role in this slow growth than they did in the wheat boom of the 1960s and 1970s, and in a way that was not easily discernible from macroscale production statistics of a very regionally diverse crop. Dharm Narain, the pioneering econometrist of Indian agriculture had argued that the primary driver of grain yields before the 1960s Green Revolution had been “locational shift”, that is by exploiting the comparative advantages of regions; rather than the “pure yield effect” which could be attributed to technology change and was what predominated in the early Green Revolution period. This “unfinished work of Dharm Narain” was the subject of considerable debate and in 1986, C.G. Ranade corrected some data anomalies and extended his work, coming to the exact opposite conclusion: locational shift was a more important factor after the 1960s than before; driven by the extension of rice cultivation in Punjab and Haryana. But as Ranade pointed out, this locational shift owed much to technical change, as it had been enabled by the adoption of short duration varieties suitable for the agricultural cycles of northwestern India.<sup>93</sup> Thus it was in the case of the slow revolution in rice rather than spectacular case of wheat that the qualitative advantages of new technologies such as plant breeding and tubewell irrigation made a significant difference.

### **The Making of a Legend**

In a speech before the Society for International Development in Washington, DC on March 8, 1968, USAID administrator William Gaud, spoke of a revolution in food production, one he called “The Green Revolution” as opposed to a Soviet Red Revolution or the Shah’s White Revolution. Thus was coined the term. A careless glance at Gaud’s speech might give one the impression that the revolution had already taken place; indeed in conclusion he asserted that “the story of the Green Revolution is not a story of failure, it is a story of success.” A closer examination reveals that speaking before the impressive 1968 wheat harvest was in, Gaud was merely predicting a revolution based on the gargantuan efforts India and Pakistan had put into enhancing wheat yields; it is highly

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<sup>93</sup> C. G. Ranade, "Growth of Productivity in Indian Agriculture: Some Unfinished Components of Dharm Narain's Work", *Economic and Political Weekly* (1986) **21**: A75-A80.

probable that his confidence also reflected knowledge that the El Nino event of 1965-67 was expected to abate, resulting in a rapid recovery of agriculture the world over. The speech was really directed at increasing the American overseas aid budget at a time when Congress had cut the presidential international aid request by 30% and scandals had “given foreign aid as much publicity over the past couple of months as the program normally receives in the course of a year”. Many claimed that foreign aid did not work, and the Green Revolution’s “story of success” provided “much evidence to the contrary”. While Gaud mentioned fertilizers and policy changes, he centred his story on an easy economic transformation that could be achieved with the dissemination of a cheap technology (seeds) developed by Western aid agencies.<sup>94</sup>

In 1969, after a successful harvest or two, Norman Borlaug wrote an article titled “A Green Revolution yields a golden harvest” asserting that technology could be more revolutionary than any “ism”. To him the Green Revolution resulted from the “transplants” of HYVs which proved that such “transplants” were possible if scientists won the battle with the government for attractive grain prices and cheaper inputs such as fertilizers and pumps. According to Borlaug, the swift spread of the Green Revolution had shattered economists’ hypothesis that revolutionary growth in agriculture could only be achieved after decades of gradual development. Like other early studies, Borlaug prevaricated when it came to evidence of the importance of the new seeds in increased production. He spoke of demonstrations of yields of 5000 kg/ha compared to a normal 700 kg/ha; a comparison applicable perhaps only between a poor Bihar farmer’s unirrigated field and a controlled experiment in Ludhiana. In a way of presentation that would become standard for propagandists of the new seeds, he stated that only 18% of the wheat acreage was sown with the new seeds in 1967-68; this produced 36% of the total harvest.<sup>95</sup> Quite apart from the question of how he ascertained these figures from India’s poor agricultural intelligence system, this was far from impressive. In 1966-67, the state of Punjab had produced 21% of India’s wheat on 9% of its wheatland and the contrast is likely to be even more impressive if production from Punjab’s irrigated

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<sup>94</sup>William Gaud’s address to the Society for International Development on March 8<sup>th</sup> 1968 at Washington, DC. Accessed online at <http://www.agbioworld.org/biotech-info/topics/borlaug/borlaug-green.html> on 10th August 2015.

<sup>95</sup> Norman Borlaug, Ignacio Navarez, Oddvar Aresvik and R. Glenn Anderson, “A Green Revolution Yields a Golden Harvest”, *Columbia Journal of World Business* (1969) 5: 9-19.

wheatland could exclusively be taken into account. Such yield differentials have long been part of India's agricultural landscape.

In 1970, Borlaug was awarded the Nobel Peace Prize. In that year, J. George Harrar, the president of the Rockefeller Foundation belatedly took credit for the Green Revolution on its behalf in its annual report. He addressed the voluminous criticism of the Green Revolution that had arisen in the short space of two years, mostly on its social and economic impact. Crucially, in conclusion he felt the need to emphasize the importance of the new seeds rather than the entire input package of cheap fertilizers, subsidized irrigation and economic incentives,

Again and again, the new seeds have shown that they have the capability of increasing production where other agricultural improvements have either failed or had little effect. In the Punjab region of West Pakistan, for example, the more progressive farmers had been installing new tubewells for several years before the Green Revolution. But at that time only the traditional varieties of grain were available to them. The increases in yield resulting from the new wells alone were very small and in many instances did not compensate the farmers for their additional inputs. However, with the introduction of the new varieties brought in by the Green Revolution, the yields of these same lands with the tubewells already installed began to increase spectacularly. In other places, before the new seeds were developed, the farmers had tried to increase their yields by buying more fertilizer and applying it to the traditional varieties. But the unimproved varieties often do not have the capability of responding to increased nutrition during cultivation, and the farmer frequently found that the expensive fertilizer did not net him any real gains in yield. When he planted the new varieties and used the additional fertilizer, he often found that his yields increased several fold.<sup>96</sup>

Thus was born "the greatest success in the history of foreign aid since the Marshall Plan".<sup>97</sup> As the 1970s wore on, there emerged the inconvenient fact that spectacular growths in yield were confined to wheat in northwestern India. It was noticed that HYV rice had a much lower penetration than dwarf wheat and thus extension staffs were given ambitious targets; as a result, the official adoption rates in some parts of India were three

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<sup>96</sup> Rockefeller Foundation, *Annual Report* (New York, NY, 1970).

<sup>97</sup> Cullather, *Hungry World*, p. ix.

times the actual rate. Scholarly studies also began to concentrate on the reason for low adoption rates, identifying the factors (including irrigation) which hampered adoption and explaining farmers' response as rational, recommending either the removal of the obstacles or the development of new varieties; agricultural development was increasingly reduced to varietal development and adoption alone. Seeds became an important concern of the international development community promoted by expert literature with titles such as *Seeds of Change*,<sup>98</sup> and the study of agricultural change became increasingly divorced from the not inconsiderable matter of production. For example a multi-volume UN study of the Green Revolution was titled *The social and economic implications of large-scale introduction of new varieties of foodgrain*. The only set of statistics in the summary volume (appropriately titled *Seeds of Plenty, Seeds of Want*) are the global area under wheat and rice HYVs, besides 2 graphs showing the production and yield of wheat in India. No mention was made of the production of rice, both Asia's and India's most important food crop.<sup>99</sup> While fertilizer use per hectare was the key quantitative measure of the level of agricultural technology in the West, in the poor world, it quickly became the area planted with HYVs.<sup>100</sup>

That the HYVs had only a marginal role to play in the Green Revolution was well known to some; indeed, only a few days after the Green Revolution speech, William Gaud noted in evidence to a Congressional committee that the seed-fertilizer technology was secondary to price policies, and that the new seeds were merely an inducement for countries to allocate more of their resources to agriculture than to industry.<sup>101</sup> Whether the new seeds even played that limited role in deceiving policymakers is questionable. While political rhetoric in India often emphasized the centrality of the scientist as embodied in the plant breeder, in their memoirs and other writings, both Agriculture Minister C Subramaniam and Secretary of Agriculture B Sivaraman are clear about the crucial role of irrigation and price incentives.<sup>102</sup>

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<sup>98</sup> LR Brown, *Seeds of Change: The Green Revolution and Development in the 1970s* (London, 1969).

<sup>99</sup> Andrew Pearse, *Seeds of Plenty, Seeds of Want: Social and Economic Implications of the Green Revolution* (Oxford, 1980).

<sup>100</sup> Dana G. Dalrymple, "The Adoption of High-Yielding Grain Varieties in Developing Nations", *Agricultural History* (1979) 4: 704-726.

<sup>101</sup> As quoted in Cullather, *Hungry World*, p. 260.

<sup>102</sup> Subramaniam, *Hand of*, p. 225.



Critics of the Green Revolution; those one might expect to take on and challenge the standard narrative put forth by enthusiasts proved on the contrary to be especially susceptible to the idea of social change being determined by innovation. A prominent example was the scholarly response to the burning alive of 43 *dalit* labourers by upper caste landowners in Thanjavur in 1968. This event, which was widely covered by the international press was quickly ascribed to the disruptive social effects of the new technology high social cost of the new technology and fears were expressed that the Green Revolution was quickly turning red. This was in fact what prompted USAID to send Francine Frankel to study the social impact of the Green Revolution. Technically something of a distanced actor account (she was also a consultant with USAID during her time in India), her study was astonishingly balanced and perceptive, if reflective of the faith in plant breeding prevalent in those heady early days.<sup>103</sup> However, no impactful visible study followed up on her work in either greater detail or in extending the story into the 1970s; Frankel's work on the Green Revolution was overshadowed by her later reputation as one of the most prominent scholars of Indian politics, with a book enriched in no small measure by access to actors afforded by Green Revolution-era assignments.<sup>104</sup> The alternative narrative wherein seeds were not central did live on in the works of many social scientists; Robert Chambers of the Institute for Development Studies for example recognized that the central agent in productivity growth was the north Indian revolution in water supply. Terming groundwater as "the last frontier", he argued that few areas of technical investment offered as much opportunity for livelihood generation as it did; control over groundwater offered an opportunity to decisively shift the balance in favour of the poor despite the unfulfilled promise of land reform. With his interest in poverty and rural development, he pioneered the discipline of irrigation sociology, engaged with Indian irrigation engineers and did much research on how best to enable equitable access to water for the rural poor.<sup>105</sup>

However, the obsession with idea of recent innovation determining social change proved remarkably resilient. The classic tale of the Thanjavur *dalit* atrocity for example,

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<sup>103</sup> Frankel, *India's Green Revolution*.

<sup>104</sup> Francine Frankel, *India's Political Economy 1947-1977: The Gradual Revolution* (Princeton, NJ, 1978).

<sup>105</sup> See Chamber's many publications especially Robert Chambers, "Beyond the Green Revolution: A selective essay", in T. Bayliss-Smith and S. Wanmali (eds.), *Understanding Green Revolutions: Development Planning and Agricultural Change in South Asia* (Cambridge, 1984), pp. 362-379.

continued to be repeated in the literature for several years, even after some of India's most senior sociologists contextualized the event as merely one particularly horrific episode in a very long history of class and caste conflict in the district.<sup>106</sup> More than in any other discipline, the standard narrative of a "Green Revolution" of booming foodgrain production driven by innovations in plant breeding has lived on in the historiography, as I've discussed in the introduction to this thesis. This is in large part due to the fact that the historiography is fairly limited, perhaps due to the implicit assumption that the standard innovation-centric story tells us all we need to know about what we take to be the defining process of twentieth-century agricultural history and contextualizing is all that historians need to do.

### **Conclusion**

An examination of the statistical record yields no evidence of any revolutionary transformation in India's foodgrain production in the late 1960s and 1970s which is implicit in accounts of the Green Revolution. There was indeed a remarkable transformation in India's the growth of production and land productivity of foodgrain; but that transformation began more or less after the Second World War and the end of colonial rule. The 1960s and the 1970s were in fact a period of slow growth compared to the 1950s.

The sole exception to this trend was the case of wheat, relatively insignificant part of India's food basket. Wheat saw a remarkable transformation in production and yields after 1950, and this trend indeed intensified from the mid-1960s onwards. While the growth in yields in the latter period, usually most identified with the Green Revolution has usually been ascribed to seed varieties imported from Mexico, this chapter has shown that the technology central to the remarkable post 1960 growth in wheat yields was a quick expansion in the area of wheat irrigated by the spread of private tubewells. Irrigation in itself contributed substantially to increased yields and also enabled further improvements such as higher fertilizer use. The new dwarf seeds were in fact inefficient users of fertilizer and equally impressive production gains could have been achieved at a lower cost by using lower fertilizer doses over a larger acreage of tall varieties. This chapter has thus challenged the key claims in both the overall productionist narrative of

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<sup>106</sup> For an overview of the Thanjavur scholarship, see Robert Chambers, "Beyond the Green Revolution", p. 370.

the Green Revolution as well as the innovation-centricity of the key case of Indian wheat production.

Being preponderant in India's foodgrain basket, trends in rice production have more or less been the same as the trend in overall foodgrain production; rice saw a revolutionary growth in yields and production in the 1950s, followed by a slowdown for a little over a decade from the mid-1960s and a less impressive revolution thereafter. After the mid-1960s, improvements and expansion of rice cultivation was slower than that of wheat and its own remarkable performance in the 1950s. In part, this was due to a change in national priorities which meant that rice was allocated fewer resources than wheat. But improvements to rice cultivation were also severely constrained by the unsuitability of the short duration, photoperiod insensitive new varieties to the systems of irrigation and cycles of monsoon endemic to traditional rice-cultivating areas. Increases in rice production took place in large part through cultivation in non-traditional regions and non-traditional seasons. The tubewells of Punjab, installed to irrigate wheat during the winter were put to use to irrigate rice during the monsoon which was scanty in Punjab and thus fields were amenable to better water management with irrigation than in traditional rice areas; Punjab became an important rice producing state cultivating the new varieties with very high yields. Similarly, the new varieties, coupled with tubewell irrigation enabled the cultivation of rice as an additional crop during the non-traditional summer season in the traditional rice areas of eastern India which also made for very high yields. This multi-regional transformation in India's rice production landscape took place more slowly and later than wheat in the 1970s, 1980s and 1990s; but the novel advantages of tubewells and new varieties played a more important role than they did in the original Punjabi wheat revolution.

The Rockefeller Foundation was quick to appropriate the spectacular harvests of the late 1960s exclusively to the HYVs developed by it, and Dr. Norman Borlaug was awarded the Nobel Prize in 1970. Few questioned the standard story of the wheat revolution as one fuelled by dwarf plant varieties, and new varieties became central to Third-World agricultural development; as exemplified by the fact that while fertilizer use is the standard index of technology in the rich world, in the poor world it is the cultivation of HYVs. Despite the disappointing promise of the Green Revolution outside of the case of wheat in Punjab (which was in any case not driven by dwarf varieties), critical scholars (historians among them) have chosen not to question the innovation-centric story told by

Green Revolution promoters. This is due to a general innovation-centred picture of science of technology, and the fact that the standard story exemplifies the idea that innovation drives social change, which is an important trope in the historical literature.

Having established the centrality of irrigation in the postwar transformation of Indian agriculture, in the next chapter I will detail the colonial origins of the tubewell, the technology crucial to that transformation. In subsequent chapters I shall also detail the role played by ideology and contingency in the selection of private tubewells as the means of irrigation-expansion in the 1960s. Having established the insignificant and likely negative role played by the High Yielding Varieties of seeds in the Green Revolution, I will also tell the story of how a seemingly inappropriate technology was promoted by the government.

## Chapter 2: The colonial origins of tubewell irrigation

The general view of colonial irrigation is encapsulated in Headrick's claim that "the official mind was attracted to projects of gargantuan dimensions".<sup>1</sup> Indeed we have several studies on the construction, operation and impact of the large canal irrigation systems in colonial India. But as I have noted in the introduction to this thesis, irrigation from tubewells has been neglected in the historiography,<sup>2</sup> even though India had the world's largest public tubewell programme in the interwar years, and ambitious plans for extending tubewell irrigation were made during and after the Second World War.

In this chapter, I shall give an overview of tubewell irrigation during the first half of the twentieth-century in India, with a focus on the remarkable career of Sir William Stampe, a British irrigation engineer. During the first quarter of the twentieth century, provincial governments attempted to promote private tubewell development, but these efforts were limited in their effect as the expensive technology was only viable for large farms and the cost of pumping with oil engines in the absence of electricity were high. In the interwar years, a breakthrough was made in the United Provinces (UP) where the Irrigation Branch under Sir William Stampe harnessed the falls of the Upper Ganges canal with power stations to build the first rural electrification programme in India. Stampe pioneered a public tubewell irrigation programme in conjunction with the grid, which was the first large-scale use of tubewells in India and the largest public tubewell programme in the world. Sir William was appointed as an Irrigation Advisor to the Government of India during the Second World War. His advocacy, together with a sense of urgency in

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<sup>1</sup> Daniel Headrick, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism 1850-1940* (New York, 1988), p. 190.

<sup>2</sup> Elizabeth Whitcombe, *Agrarian Conditions in Northern India Volume One: The United Provinces under British Rule, 1860-1900* (Berkeley, Ca, 1972), Ian Stone, *Canal Irrigation in British India: Perspectives on Technological Change in a Peasant Economy* (Cambridge, 1985), Imran Ali, *The Punjab Under Imperialism, 1885-1947* (New Delhi, 1987), M. Mufakharul Islam, *Irrigation, Agriculture and the Raj: Punjab, 1887-1947* (New Delhi, 1997), David Gilmartin, "Scientific Empire and Imperial Science: Colonialism and Irrigation Technology in the Indus Basin", *The Journal of Asian Studies* (1994), 53: 1127-48. For an overview see Elizabeth Whitcombe, "Irrigation" in Meghnad Desai and Dharma Kumar (eds.), *The Cambridge Economic History of India* (Cambridge, 2005). For a literature review, see Rohan D'Souza, "Water in British India: The Making of a 'Colonial Hydrology'", *History Compass* (2006) 4:621-628.

increasing food production during and after the Second World War was crucial in putting tubewells on the central government agenda.

I shall argue that tubewells (and groundwater irrigation more generally) became progressively more important during this period at the local, provincial and national scale due to the notion that the possibilities for the cheap extension of surface irrigation were close to exhaustion, and due to emergency needs to extend irrigation faster than was possible with canal systems. During the Second World War, colonial administrators saw India's food problem as one of wartime production and saw tubewells as a quick means of increasing the irrigated area and stimulating food production. While William Stampe pushed tubewells as an emergency fix, he saw India's vast groundwater reserves as a strategic resource and his vision for tubewells in India was a grander one than could be carried out during war.

I shall argue that his was a small-scale, rural-agricultural vision for electricity in India that was in sharp contrast to the large-scale, urban-industrial vision of dominant nationalist planners. I shall illustrate how colonial engineers such as Stampe took great interest in small projects, prioritized the needs of the countryside and took pride in their service to small-scale industries. This small-scale, rural-agricultural vision for electricity was contested by nationalist technocrats such as Meghnad Saha, who saw electricity as a large-scale, urban-industrial technology. Gandhi's oft quoted view was that he did not mind villagers using electricity to ply their implements as long as the power houses were state owned.<sup>3</sup> I shall argue that the Ganges grid was a colonial vision for electricity that would have been more acceptable to Gandhi than the vision of dominant nationalist planners. While Stampe later envisioned a massive transformation of the Indian

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<sup>3</sup> As quoted in Deepak Kumar, "Reconstructing India: Disunity in the Science and Technology for Development Discourse, 1900-1947", *Osiris* (2000) 15: 241-257 who also suggests that Gandhi was politically important to the British in this context, as does Benjamin Zachariah, *Developing India: An intellectual and social history* (New Delhi, 2005), p. 114 who says that "village uplift" was a sphere imperialists and non-imperialists could cooperate on; colonial administrators were sympathetic to the non-political "bona fide village welfare work" of Gandhi. For the debate on Gandhian ideas, their marginalization and subsequent nationalist debates about development which were almost exclusively about the modes of large-scale industrialization (socialism, capitalism etc.) see Zachariah, *Developing India*, pp. 156-290. Gyan Prakash, *Another reason: science and the imagination of modern India* (Princeton, 1999), p. 197 too argues that the Congress Party's National Planning Committee which was initiated by Saha "set about immediately to quash Gandhian objections to large-scale industrialization."

countryside, his attitude towards scale was one of gradualism and experimentation, of starting small and scaling up if the experiment was successful; illustrating one irrigation engineer's caution and thoughtfulness when it came to large-scale intervention into natural hydraulic regimes.

## I

While there has been some mention of wells, the historiography of irrigation in colonial India has largely focused on large surface irrigation systems.<sup>4</sup> Elizabeth Whitcombe has mentioned a small project that harnessed canal falls in Punjab to power 10 tubewells to remedy waterlogging in the 1910s and has attributed the failure to expand the scheme to the hostility of the irrigation establishment to power production and the low demand for power in an agricultural province. She has also mentioned the tubewells of the Ganges grid but seen the project more as more of a power production than an irrigation venture. But neither this nor other passing mentions gives a proper indication of the scale and scope of the UP tubewell programme.<sup>5</sup>

The literature on electrification also does not give adequate coverage to such schemes. Rao and Lourdasamy have argued that colonial electrical engineers in Madras were only "interested in everything big" such as big power plants and large industrial consumers, a vision contested by Indians who preferred smaller projects which sought to bridge the urban-rural divide by promoting rural and cottage industries.<sup>6</sup>

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<sup>4</sup>The relative merits of canal and well irrigation are sometimes central to the argument in works focusing on canals. Whitcombe, *Agrarian Conditions* has lamented the decline in well irrigation in the canal-irrigated tracts of UP, while Stone, *Canal Irrigation* has celebrated that decline, arguing that canals were an "appropriate technology".

<sup>5</sup> Whitcombe, "Irrigation", pp. 730-734. In the Punjab case, Islam, *Irrigation* has argued that the initial decline in well irrigation due to the advent of canals was not so pronounced as in UP, and that decline was reversed in the twentieth century with the introduction of Persian Wheels, the boring of wells and introduction of tubewells on a small scale, though well irrigation continued to be expensive except in rare cases where water was lifted with oil engines or electricity. Ali, *The Punjab Under Imperialism* has noted small private efforts to harness canal falls in Punjab to power tubewell irrigation and argued that the absence of large-scale electrical development in Punjab, together with the colonial administration's recourse to intermediaries to effect agricultural improvement precluded tubewell development.

<sup>6</sup>Srinivasa Rao and John Lourdasamy, "Colonialism and the Development of Electricity: The Case of Madras Presidency, 1900 -47", *Science, Technology and Society* (2010) **15**: 46.

### **Forged in war: An early global history of the tubewell**

A tubewell consists of two pipes in series inserted into the ground and used in conjunction with a pump. The first section through the dry strata close to the surface is a standard steel pipe, while the second section within the water bearing strata is slotted and is called the strainer; this allows the water to be pumped but keeps out the sand. A tubewell is typically quicker to install than dig a conventional well; in addition, it taps rich deep aquifers enabling a more copious and continuous supply. The device is most suitable for alluvial aquifers.

While devices and methods of water supply akin to the tubewell had been developed since the early nineteenth century, it was in the 1860s that the device first found significant visibility when it was used on the move by the Northern Army during the American Civil War. In 1865, Thomas Dutton and Thomas Maguire of New Jersey patented the device and commentators saw the ease of installation and the protection of water from contamination (both problems with conventional dug wells) as its key advantages.<sup>7</sup>

This “American Tube Well” was licensed by JL Norton of Manchester who made improvements to methods of driving the pipes into the ground; patenting these in England in 1867 and 1868 as the “Norton’s Patent Tube Well” After successful testing in Chatham, the army bought 50 of Norton’s tubewells (to which another 50 were added) in 1867 for the Abyssinian expedition. The official record of the expedition had a detailed description of the operation of the new device and noted that the tubewell proved to be an “exceedingly ingenious method of boring into any material short of solid rock”.<sup>8</sup>

The success of the tubewell in that expedition got much popular press. As early as 1868, *Mechanics Magazine* wrote that the Norton tubewell had “gained such notoriety” that a description was not necessary; it termed the device “The Abyssinian tube well”, a name which stuck.<sup>9</sup> 1868 was a year of drought in England making for great interest in the new device; a Bath journal wrote that the apparatus showed that the farmer need not lie idly

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<sup>7</sup> Anon., “Dutton and Maguire’s Pipe or Tube Well”, *American Artisan and Patent Record* (1867) V: 152.

<sup>8</sup> Trevenen J. Holland and Henry M. Hosier, *Record of the Expedition to Abyssinia: Volume 2* (London, 1870), p. 286.

<sup>9</sup> Anon., “The Abyssinian Tube Well”, *Mechanics Magazine* (1868) XX: 344.



seeing his cattle languish for water.<sup>10</sup> In that same year, agricultural journals publicized the tubewell all over the British Empire including in an article in the *Madras Times* which emphasized its value for irrigation and the fact that Indian Army personnel who had returned from Abyssinia could help with advice.<sup>11</sup> The Punjab government even wrote to London requesting to be supplied with six Norton's tubewells in conjunction with steam driven pumps for experiments with irrigation.<sup>12</sup>

The tubewell saw much use in the nineteenth-century by armies on the move, for watering animals and for domestic, municipal and industrial water supply, including within England where Le Grand and Sutcliffe of London had bought Norton's patent and improved upon it.<sup>13</sup> However, it saw little use for irrigation in early decades. This was perhaps because of the lack of a cheap and convenient source of motive power that could deliver the massive quantities of water demanded by agriculture. It was only from the turn of the twentieth century that the device began to be used in the United States for irrigation in California and the High Plains by individual farmers, initially with the spread of boring technology and windmills and later with the availability of oil engine and electric pumps. An early experiment was in Garden City, Kansas where an electricity plant powered 23 pumps starting in 1908 which irrigated 5-6000 acres before the government sold the system to the Garden City Company which operated it indifferently.<sup>14</sup> The use of private pumps however did spread on the High Plains; by 1939, 250,000 acres were estimated to be under pump in Texas.<sup>15</sup> By then however, developments in America had been overtaken by the spectacular rise of public tubewells in northwestern India as I will show in a subsequent section.

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<sup>10</sup> Anon., "The Year 1868 and its Agricultural Lessons", *Journal of the Bath and West of England Society* (1868) **XV**: 204-205

<sup>11</sup> Reprinted from the *Madras Times* in Anon., "The Cultivator's Friend", *Madras Revenue Register: Volume 2* (1868), p. 325.

<sup>12</sup> Request of the Punjab Government to be supplied from London with six Nortons tube wells for experimental use in irrigation work in the Punjab in British Library File IOR/L/PS/6/566.

<sup>13</sup> Anon., "Advert for Norton's Abyssinian Tube Wells, 1884", British Library Website accessed online at <http://www.bl.uk/onlinegallery/onlineex/evancoll/a/014eva000000000u07442000.html> on 10th August 2015.

<sup>14</sup> John Opie, *Ogallala: Water for a Dry Land* (Lincoln, Ne, 1993), p. 54-91.

<sup>15</sup> Donald E. Green, *Land of the Underground Rain: Irrigation on the Texas High Plains, 1910-1970* (Austin, TX, 1973), p. 91.

### **Groundwater irrigation in early twentieth-century India**

At the turn of the century, 19.5% of the area annually cropped in British India was under irrigation. Only 42.2% of this area was irrigated by state-owned works while private canals, tanks and wells accounted for the rest. Government canals contributed 35.5% of the total irrigated area, while private wells accounting for 29.2% were a close second. Of the nearly 13 million acres irrigated by wells the Indo-Gangetic plains provinces of UP (with 5.7 million acres) and Punjab (with 3.75 million acres) together accounted for over two thirds; Madras (with 2 million acres) in the South was a distant third.<sup>16</sup>

Provincial governments across India had various policies in place to promote well irrigation including loans and tax breaks. On an all-India basis, of the Rs. 277 lakhs of loans advanced to cultivators by the government for land improvement during the decade ending in 1900-01, Rs. 242 lakhs was for irrigation improvement.<sup>17</sup> UP had also begun assisting agriculturists with the boring of wells to increase their yield while the Madras government had developed a very liberal system of government loans for well construction, in addition to a commitment to not increase revenue rates due to land improvement from wells. Even in canal-irrigated areas, there were some attempts to encourage well irrigation; for example, the commitment to construct a well to tide over failure of the rains or canal supplies was a condition of entry into some Punjab canal colonies, and Gujarat was toying with the idea of making well construction a condition for permitting the cultivation of sugarcane in canal-irrigated tracts.<sup>18</sup>

As wells could be constructed fairly quickly to aid agricultural production, they invariably become the focus of drought relief efforts; in UP for example, of the 550,000 new temporary wells constructed during the drought of 1896-97, it was estimated that over half were constructed with government aid; this was in addition to the construction and repair of thousands of permanent wells.<sup>19</sup> Thus not only did the kind of wells vary considerably among the provinces, but the area irrigated by wells varied considerably from year to year; in UP for example, irrigation from wells varied between 3 million acres in a year of good rain to over 7 million acres in a drought year.<sup>20</sup>

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<sup>16</sup> Indian Irrigation Commission, *Report of the Indian Irrigation Commission, Part I* (London, 1903), p.12.

<sup>17</sup> Indian Irrigation Commission, *Report of the Indian Irrigation Commission, Part II* (London, 1903), p.199.

<sup>18</sup> Irrigation Commission, *Part II*, p.202.

<sup>19</sup> Irrigation Commission, *Part II*, p. 199.

<sup>20</sup> Irrigation Commission, *Part II*, p. 199.

The largest share of what could be called development expenditure in colonial India of course consisted of large-scale government owned surface irrigation schemes, but there was substantial disquiet over the utility of this investment. The Famine Commission of 1879 had concluded that while there were parts of India where agriculture would be impossible without irrigation, there were others where irrigation proved neither remunerative to the state nor served as protection from famine. The droughts of the 1890s, together with the consequent famines shook the confidence in irrigation as a universal famine prevention measures and an Irrigation Commission was appointed to decide the future course of irrigation projects.<sup>21</sup>

The Indian Irrigation Commission (1901-03) with its focus on the “limitation of irrigation”<sup>22</sup> came very close to questioning the orthodoxy that irrigation was the most important technology for Indian agriculture; pointing out that if one accepted that the government should bear the cost of irrigating one man’s acre, there was nothing preventing another man to demand that it bear the cost of manuring his field. More generally, it pointed to several technical and financial difficulties which it felt would limit the viability of new large-scale surface irrigation projects: the geographical and surface distribution of rainfall would necessitate substantial storage structures which would be expensive. On the flat plains of Northern India, such a structure would submerge about the same area it could irrigate; in the Western Ghats, not only would the cost be too high, but entire towns and villages would need to be uprooted and safety could still not be assured. The Commission admitted that many of these difficulties could be overcome if cost was of no consequence; but argued that even when the object was famine prevention, there was a limit to the cost the general community could be expected to bear to protect any given tract. Further, as droughts were not predictable, the Commission felt that it would be wasteful to conserve water (rather than use it fully to irrigate) in a reservoir for a drought that might or might not strike the next year.<sup>23</sup> While the Commission did relent in accepting a fairly large programme of work for the Irrigation Departments, it acted to limit the enthusiasm for large projects by showing that most of the new irrigation projects proposed by the departments would not meet the strict criteria it recommended for the selection of new projects.

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<sup>21</sup> Whitcombe, "Irrigation", p. 700.

<sup>22</sup> Irrigation Commission, *Part I*, p. 4.

<sup>23</sup> Irrigation Commission, *Part II*, pp. 6-25.

The Commission was however extremely enthusiastic about private wells as a means to increase irrigation; arguing that these were at least as important as large publicly-owned works and there was no province in India where well irrigation could not be extended at great advantage. It estimated that only 1.5% of the water which percolated into the soil was used, and thought that the number could be quadrupled. The Commission noted that well irrigation too had some limitations such as the total water available, but while it opined that the extension of well irrigation had to be gradual and in keeping with the general development of cultivators' resources, it predicted that well irrigation would continue to grow "long after the extension of irrigation by flow had ceased." The Commission did not consider it "over-sanguine" to envisage an eventual doubling of the area under well irrigation in India.<sup>24</sup>

The Irrigation Commission recommended several measures for the government to encourage well irrigation. The first was a liberalization of government loans for well construction. This required lower interest rates, a sympathetic and less rigid collection of repayments and longer loan tenures, besides the prevention of corruption by "underlings" while granting loans. Making tenancy rights transferrable was also desirable to enable the same to be used as a collateral by tenants. In addition to these loans, it also recommended outright grants for well construction and opined that governments should share the risk of well construction by compensating farmers for failed wells. It further recommended that land improved as a result of well construction should be exempted from increased taxation. In addition to these financial measures, the Commission recommended that the provinces set up agencies to assist cultivators with the sinking and boring of wells. Finally it emphasized the need for a survey of artesian water supplies through a programme of trial borings.

By the mid-1920s, some of the provinces had set up establishments to aid cultivators with equipment for the boring of wells. There were also technological changes, albeit on a very small scale. The Irrigation Commission had noted the use of two steam engines for pumping water in Gujarat; the use of pumps grew in that province. In Madras, experiments in pumping with oil engines started in 1903 by Alfred Chatterton, the Director of Industries, led to a programme of loans to cultivators which had assisted with 173 engines and pumps by March 1926. However, motorized groundwater irrigation in that province faced great challenges due to the low availability of water; this meant that

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<sup>24</sup> Irrigation Commission, *Part I*, p.28.

wells often ran dry after a mere hour of pumping. Consequently, a programme of boring and deepening of wells to increase their capacity was in progress in Madras.<sup>25</sup>

UP and Punjab had already been using aspects of tubewell technology when the Irrigation Commission had reported in 1903. In UP's permanent wells, the practice was to dig through the upper strata of clay, loam and sand until the impervious clay bed was reached. A hole would be bored through the clay bed to the sandy confined aquifer below and water would rise to the level of the well under sub-artesian pressure. In Punjab, a strainer pipe would be inserted through this bore to substantially augment the capacity of the well.<sup>26</sup> When, by the 1920s, the tubewell proper had begun to solve the problem of having an uninterrupted supply of water copious enough to be pumped, these prior improvements of the well in fact made for some confusion as to what exactly a tubewell was; when asked by the Royal Commission on Agriculture in India (1928), the Agricultural Engineer to the Government of Punjab replied that it was merely the magnitude of the discharge that distinguished a tubewell from an open well. In any case, by the 1920s, the tubewell proper had begun to solve the problem of an uninterrupted supply of water copious enough to be pumped.<sup>27</sup>

Having set up a well boring unit pursuant to the Indian Irrigation Commission's recommendations, the Punjab government grew warm to the idea of tubewells and appointed TA Miller Brownlie as the Agricultural Engineer to the Government in 1915. Brownlie had previously experimented with tubewells for municipal water supply in Amritsar and had himself invented a cheap strainer. In addition to a program of improving open wells, between 1915 and 1927, the Punjab Agricultural Department had assisted 21 cultivators with sinking tubewells operated with oil engine pumps. The government was planning an experiment of putting down a battery of 16 tubewells with electric pumps to be tentatively powered by a small generator to study the economics of tubewell irrigation.<sup>28</sup>

The UP Agriculture Department had embarked on a more substantial programme of assisting and encouraging tubewell irrigation. As the province had exhausted most large-scale surface irrigation sources, it was felt that the use of underground water through

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<sup>25</sup> Royal Commission on Agriculture in India, *Interim Report, Volume III: Evidence taken in the Madras Presidency* (London, 1927), p. 231.

<sup>26</sup> Irrigation Commission, *Part II*, p.48.

<sup>27</sup> Royal Commission on Agriculture in India, *Interim Report, Volume VIII: Evidence taken in the Punjab* (London, 1927), p. 187.

<sup>28</sup> Royal Commission on Agriculture in India, *Interim Report, Volume VIII*, p. 183-188.

tubewells was the only means to extend irrigation. By 1927, when the Royal Commission on Agriculture in India collected its evidence, the department had assisted in the construction of 200 tubewells, which were estimated to be irrigating 30,000 acres every year. Tubewell construction was heavily subsidized by the provincial government; besides loans, it provided grants-in-aid of upto Rs. 3000 and a “tubewell subsidy” of Rs. 6,000. In addition, the well was bored for free by the Department, a job which would have cost an estimated Rs. 16,000 if carried out privately and the farmer only paid for the pipes and the pump actually left in his possession.<sup>29</sup>

Being expensive, tubewells were thought to be suitable only for intensive cultivation; in fact they were seen as a “powerful influence” in favour of the same.<sup>30</sup> Operational costs being high, they were thought viable only for high value crops such as sugarcane, potato and tobacco, and unsuitable for wheat and rice. There were other problems; the cost of pumping water with kerosene engines, while lesser than that of raising water by draught animals, was still very high. Thus like Punjab, the UP Agriculture Department too was also planning an experiment with 10 electrically powered tubewells in Gorakhpur.<sup>31</sup>

Further, tubewells were found to be viable only for farms of at least 150 acres and could sometimes irrigate upwards of 500 acres; as the Agricultural Engineer to the UP Government Mr. Vicks admitted, his well boring agency was “working for rich men”.<sup>32</sup> To him, the only difficulty in extending tubewell irrigation was one of finance; he argued that if the government could raise loans to construct canals, it could do the same for tubewells. In a note submitted to the Royal Commission on Agriculture in India in the late 1920s, he proposed a Lift Irrigation Department “far bigger than even the present canal departments”, which would sink tubewells and sell the water to small cultivators.<sup>33</sup> Fantastical as the vision was, publicly-owned tubewells powered by electricity would quickly become very important in UP. That initiative however came from the Irrigation Department, whom Vicks had opined against entrusting the work to, fearing it would obscure the importance of tubewell irrigation.<sup>34</sup>

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<sup>29</sup> Royal Commission on Agriculture, *Volume VII: Evidence Taken in the United Provinces*, p. 237-245.

<sup>30</sup> Royal Commission on Agriculture, *Volume VII*, p. 239.

<sup>31</sup> Royal Commission on Agriculture, *Volume VII*, pp. 237-245.

<sup>32</sup> Royal Commission on Agriculture, *Volume VII*, p. 241.

<sup>33</sup> Royal Commission on Agriculture, *Volume VII*, p. 241.

<sup>34</sup> Royal Commission on Agriculture in India, *Volume VII*, p. 241.

### The Ganges grid<sup>35</sup>

With the completion of the Sharda canal in the 1920s, there seemed to be little scope for an easy expansion of canal irrigation in UP. Extension of surface irrigation would require the building of expensive Himalayan reservoirs which were expected to be unstable and silt up soon.<sup>36</sup> A possible means to extend irrigation was by pumping water, either from low lying rivers or from the subsoil aquifer using tubewells. The falls of the Upper Ganges canal which had been previously used for flour milling<sup>37</sup> could be harnessed to produce cheap electricity for pumping. In 1927, at the initiative of William Stampe, a superintending engineer at the Irrigation Department, a project began to harness four falls on the canal to supply power to pump water from the Ramganga river to irrigate high ground and to enhance the water supply in the Upper Ganges canal itself by pumping water into it from the Kali Nadi river. The total planned generating capacity was 5700 kilowatt with the pumps on the Kali Nadi and Ramganga being the largest loads on the system.<sup>38</sup> The transmission system connecting these power stations and pumping installations was to be developed to electrify towns, villages and rural tracts in seven western UP districts spread over 10,000 square miles;<sup>39</sup> this became the first rural-electrification programme in India.

From 1927-28, the Irrigation Department began experimenting with tubewells powered by the grid.<sup>40</sup> Much advantage was seen in the ability of tubewells to irrigate areas far from the reach of canal systems and in the flexibility of a tubewell programme which could grow slowly with demand, unlike canals which required massive investment before

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<sup>35</sup> This section draws substantially from my master's thesis. See Kapil Subramanian, *Canals, Sugarcane and Tubewells: System Building in an Agrarian Economy* (Unpublished M.Sc. dissertation, Imperial College, London, 2011).

<sup>36</sup> William Stampe, *The Ganges Valley State Tubewell Irrigation Scheme: a system of state irrigation by Hydroelectric power from underground sources, 1934/35 to 1937/38* (Allahabad, 1936), p. 28.

<sup>37</sup> See Whitcombe, "Irrigation", p. 730 and *Irrigation Administration Report of the United Provinces* (Allahabad, 1902-1946), for trends of earning from Upper Ganges Canal water power sales.

<sup>38</sup> William Stampe, *The Ganges Canal Hydro-electric Scheme: A System of Rural Electrification from Low Head Canal Falls* (Roorkee, 1931), p. 3.

<sup>39</sup> United Provinces Public Works Department, *Irrigation Administration Report of the United Provinces, 1927-28* (Allahabad, 1928), p. 72.

<sup>40</sup> Public Works Department, *Administration Report, 1927-28*, p. 47.

a single acre was irrigated.<sup>41</sup> By the late 1930s, there were 1500 state tubewells on the grid each irrigating about 400 acres of land. State-owned groundwater irrigation grew to be very important in UP, irrigating 583,000 acres in 1938-39; about a third as much area commanded by the Ganges Canal and about 11% of the total area irrigated by the Irrigation Branch that year.<sup>42</sup> This made it not just (perhaps an order of magnitude) larger than any organized public groundwater irrigation system but also made western UP the world leading region in motorized groundwater-irrigated acreages.

By the late 1930s, this network of state-owned tubewells became the primary load on the electrical system, totalling nearly 20,000 horsepower.<sup>43</sup> To serve these tubewells, capacity of the generating system had to be more than quadrupled to 27,900 kilowatt between 1935 and 1939, by expanding the existing stations, harnessing four more canal falls and building a large coal-fired plant.<sup>44</sup> Over half the post-expansion capacity of the grid was to be allocated to agriculture, largely for state tubewells, but also for private tubewells and river pumps.<sup>45</sup> The Ganges grid thus made for a relationship between electricity and irrigation rather different than that conveyed by the conventional picture of co-production at a big dam where power was produced and irrigation canals led off; an existing irrigation system was used to produce power *for* irrigation, forming a new *irrigation system* of canals, power stations, transmission lines, river pumps and tubewells. Contemporary engineers such as JW Meares saw the use of power for irrigation rather than rural electrification as the breakthrough the Ganges grid planners had achieved,

Water and electricity had more than celebrated their silver wedding; the first hydro-electric scheme had been executed as long ago as 1898, and much progress has been made. The present scheme was, however, a totally new departure...The whole outlook which it symbolized was new. It was partly gratifying to [Stampe] because, in the report of the Hydro-Electric Survey of India published many years ago, he had indicated the great importance of irrigation to uncommanded areas,

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<sup>41</sup> Stampe, *The Ganges Valley State Tube-well Irrigation Scheme*, p. 28.

<sup>42</sup> Public Works Department, *Administration report, 1938-39*, p.38.

<sup>43</sup> Stampe, *The Ganges Canal Hydro-electric Scheme: A system of Rural Electrification from Low Head Canal Falls. Ultimate Development 1935-38* (Allahabad, 1935), p. 25.

<sup>44</sup> Public Works Department, *Administration Report*, p.7. This was in addition to 1885 kilowatt of Oil Engine Backup.

<sup>45</sup> Stampe, *Ultimate Development 1935-38*, p. 21.



areas above the level of gravity canals, which could be carried out from the falls of the present great irrigation canal systems of India. The new irrigation ... [will be] extended to many other parts of India and prove to be of magnificent service to the country and a fine thing for the Government.<sup>46</sup>

Tubewells made for a rural electrification very different from the domestic and industrial modernization stories told of the west; by 1938-39, the grid earned half its revenues from power sales to state-owned irrigation pumps even as they paid lower tariffs than industrial and domestic consumers.<sup>47</sup> It was power applied to agriculture that rendered viable the electrification of small towns, a picture rather different from the notion that rural electrification is a non-paying proposition that must be pushed by politics. The centrality of the tubewell to rural electrification pioneered on the Ganges grid continued in postcolonial India; it is only in the present century that the Indian government's emphasis has shifted from powering groundwater irrigation to village electrification more generally.<sup>48</sup> The finances of several state power entities have come to depend on tubewell politics; a relationship some have termed the energy-irrigation nexus.<sup>49</sup>

The Ganges Valley State Tubewell Irrigation Scheme also pioneered publicly-owned groundwater irrigation systems. The India Irrigation Commission (1901-3) had seen wells as a private enterprise while the Royal Commission on Agriculture in India (1928) had explicitly censured the UP Agriculture Department's high subsidies for tubewell development, arguing that the government's role should be limited to techno-economic studies, technical advice and loans; it opined that "private enterprise in these matters should not be discouraged by government competition".<sup>50</sup> Stampe made the case for a

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<sup>46</sup> JW Meares, "Comments on 'The Ganges Canal Hydro-electric Scheme: A system of Rural Electrification from Low Head Canal Falls.'" *Journal of the Royal Society of Arts* (1931) **79**: 835.

<sup>47</sup> Public Works Department, *Administration Report 1938-39*.

<sup>48</sup> Until recently, the object of rural electrification in India was "groundwater exploration and energization of pump sets/tubewells which has a bearing on agricultural production" rather than "village electrification" more generally. Ministry of Power, <http://www.powermin.nic.in/>, accessed on 15th May 2012. See the section on rural electrification.

<sup>49</sup> T. Shah, C. Scott, A. Kishore and A. Sharma, *Energy-irrigation nexus in South Asia: improving groundwater conservation and power sector viability* (Colombo, 2003).

<sup>50</sup> Royal Commission on Agriculture in India, *Abridged Report* (Calcutta, 1928), pp 38-39.

state-owned system by claiming that despite heavy propaganda, zamindars maintained that irrigation, whether through canals or tubewells must be the responsibility of the state, and could not be induced to construct tubewells for their tenants' use. Stampe argued that in any case, it would have been difficult to evolve a viable transmission scheme embracing scattered tubewells here and there; economic transmission was based on a minimum demand per mile of line and no scheme that traversed long distances from one enterprising zamindar's land to the next with little intervening load could pay its way. What was called for was a state-owned system, with tubewells spaced a standard 1.4 miles apart.<sup>51</sup>

Not only did Stampe argue for a public tubewell system, he also attempted to monopolize groundwater irrigation in the state tubewell tracts through a UP Underground Waters Bill. Indians in the provincial council saw the bill as an attempt to abrogate the constitutional rights of zamindars to sink wells, calling it "confiscation without compensation"; the principle of which Jawaharlal Nehru, then barely a year out of jail, "had constituted himself to be the highest priest." Eventually, only a weak toothed State Tubewells Act was passed, which afforded tubewells the same legal status as canals.<sup>52</sup> Despite the lack of a monopoly, state-owned tubewells contributed the lion's share of UP's tubewell-irrigated area.

The Ganges grid put in sharp focus the contrast in the development visions of colonial engineers and technocratic nationalist planners such as Meghnad Saha. "Small" is the word that could perhaps best characterize a planned system with an initial capacity of just 5700 kilowatt spread over 4 power plants<sup>53</sup> The "smallness" of the Ganges grid system

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<sup>51</sup> Stampe, *The Ganges Valley State Tubewell Irrigation Scheme*, p. 5.

<sup>52</sup> This afforded to the tubewells the same legal status as afforded to canals under the North India Canal and Drainage Act of 1873. Tubewells had earlier been covered under the weak toothed UP Minor Irrigation Act of 1920. The discussion, coming soon after the Government of India Act of 1935 which famously lacked a preamble, also touched upon whether constitutional law applied at all in India. Tubewells were initially defined to include all motorized wells in addition to artesian wells. Anon, *Collection 58/17 Irrigation - United Provinces State Tube - Wells Act 1936 (1936-37)* in India Office Records and Private Papers Collection, British Library, London. Reference: IOR/L/E/9/387. This new canal-like legal status would allow, for example, the power to prosecute water thieves.

<sup>53</sup> Stampe, *The Ganges Canal Hydro-electric Scheme*, p. 4. The generation capacity would be dwarfed even by projects within India, such as a concurrent effort in Madras whose first plant generated about 19,000 kilowatt in 1933 and a second plant added

was a source of pride; a picture of the Palra station with a head of 9 feet was captioned "probably the lowest fall installation in India".<sup>54</sup> Within the small system, individual generation plants would be smaller still and the generation capacity could grow slowly with the development of these small stations en route the main transmission line as the load developed without overcapitalization of the project at any point, a feature appreciated by other colonial engineers such as JW Meares.<sup>55</sup> Meghnad Saha however, saw Stampe's decision to develop small canal falls as the function of an irrigation engineer's limited vision and argued for a large project in the Himalayas.<sup>56</sup>

Like the generation system, "small" is the word that best describes the industrial power installations; a total of 2670 horsepower or half the total connected industrial load was installed in 270 flour mills averaging less than 10 horsepower each.<sup>57</sup> Most electrical power was employed in the production process outside of what can strictly be called a factory setting; for example, within the entire grid area there existed only one flour mill (compared to the 270 electrified) large enough to be classified as a factory.<sup>58</sup> William Stampe, took pride in the scheme's success in supplying small consumers,

It has been alleged that the difficulties of supplying a small amount of energy to a larger number of urban consumers especially on the industrial side has militated against the success of the scheme. From an examination of the figures there appears to be no ground for this fear. The fact that out of 635 private motors

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30,000 kilowatt in 1937 (both plants were later expanded) or Tata's Andhra Power whose capacity was 99,000 kilowatt in 1922, see Central Board of Irrigation, *Hydro-electric development in India* (leaflet, New Delhi, 1948).

<sup>54</sup> Public Works Department, *Administration Report, 1929-30*, p. 9. It must also be noted that in comparison to even other small systems, this one was unique, most small systems would use high head, low flow rate sites to supply power (say) to small mountain towns. Low heads pose particular design, construction and operation challenges. See F.E. Bull and J.W. Meares, *The Hydro-electric Survey of India Volume II* (Calcutta, 1920).

<sup>55</sup> JW Meares, "Comments", p. 835.

<sup>56</sup> K. T. Shah, *Report of the Sub-Committee on Power and Fuel* (Bombay, 1949), pp. 58-60.

<sup>57</sup> See J.P. Srivastava, *United Provinces Industries Reorganisation (Srivastava) Committee 1932-34 Report* (Allahabad, 1934), p. 46-48.

<sup>58</sup> United Provinces Labour Department, *Annual Report on the Administration of the Factories Act in the United Provinces* (Allahabad, 1931-39).

consumers in the grid area, 520 or 82 per cent have installations of not more than 10 horsepower is in itself sufficient proof of this.<sup>59</sup>

A power installation of less than 10 horsepower was also the criteria that the nationalists would soon use to define a "cottage industry," which was Gandhi's preferred mode of production.<sup>60</sup>

The Irrigation Branch also experimented with small-scale sugar production using electricity, but most electric power employed in sugarcane processing was in a hundred odd small crushing plants producing *gur* and *khandsari*.<sup>61</sup> Stampe believed that,

The secret of the successful development of this scheme appears to be the cheapness of the power offered especially in the case of isolated and small consumers... [It] is bound to result in the development of many agricultural processes hitherto beyond the reach of the rural agriculturist.<sup>62</sup>

To Saha however, the idea that electricity could be part of a rural-agricultural modernity rather than an urban-industrial one was anathema. He wrote,

Most of the existing load is agricultural and lasts for a comparatively short time. Since from the very beginning the cry had been raised of helping the agriculturists, such an unremunerative agricultural load has to be given preference, and no industrial load is sought for. Thus the main advantage of the [hydro-electric] Systems of supplying large blocks of electrical power at a very cheap rate for running industries has been nullified.<sup>63</sup>

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<sup>59</sup> William Stampe, "Note on Hydro-electric Development", in J.P. Srivastava, *Industries Reorganisation*, p. 14A.

<sup>60</sup> K. T. Shah, *Report of the Sub-Committee on Rural and Cottage Industries* (Bombay, 1948), p. 52.

<sup>61</sup> *Gur* consists of cakes of unrefined sugar made by open pan boiling of sugarcane juice on the farm. *Khandsari* is "Low quality" refined sugar produced by open pan boiling followed by manual centrifuging. Overall sugarcane processing accounted for less than one sixth of the total industrial load. Seven of the nine steam driven sugar mills in the grid area had installed a total of 250 horsepower by 1933. In addition 104 small crushing plants and centrifugals had installed 600 horsepower of electric motors to produce *gur* and *khandsari*.<sup>61</sup> Stampe, "Note on Hydro-electric Development", p. 9A.

<sup>62</sup> Stampe, "Note on Hydro-electric Development", p. 13A.

<sup>63</sup> Shah, *Power and Fuel*, p. 61.

### **An Empire at War: The Irrigation Adviser to the Government of India**

After over thirty years of service in UP, Sir William Stampe retired as Chief Engineer and went home to Britain in 1938. In 1940, he was engaged as a consultant on some tubewell projects in the princely states of Baroda and Jodhpur. En route back to Britain, he discussed tubewells for military water supply in Cairo with Major General Hughes and the possibility of a hydro-electric power and tubewell irrigation project on the lines of the Ganges grid with the Egyptian authorities. Marshall Balbo in Tripoli was also interested in his advice on lowering the cost of tubewell irrigation.<sup>64</sup> However, it being April 1940 with the imminent prospect of war on the Italian frontier, Stampe's paperwork to fly from Cairo to Tripoli was cancelled and he hurried home to be commissioned into the RAF Voluntary Reserve.<sup>65</sup>

In February 1943, prompted perhaps by the food crisis then developing in India, Sir William wrote to the Secretary of State in London with ideas for irrigation projects in India that could be executed speedily during the war; as a result of this he was appointed as an Irrigation Advisor to the Government of India attached to the Department of Education, Health and Lands (and later to the Department of Agriculture after its formation).<sup>66</sup> For Stampe, the creation of a new appointment in India after his retirement

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<sup>64</sup> William Stampe, "Emergency Irrigation Projects in India. Memorandum dated 25th May 1943 on suggested procedure for his Indian tour, by F/Lt. Sir William Stampe, C.I.E., Irrigation Adviser to Government of India", 25 May 1943, in National Archives of India (NAI) file: Question of Availing Sir William Stampe's services in connection with emergency irrigation works in States.

<sup>65</sup> Sir William Stampe to Sir AV Alexander, 25 August 1947, In Churchill Archives Centre, Cambridge file AVAR 5/12.

<sup>66</sup> William Stampe, "Emergency Irrigation Projects" The year of his appointment raises obvious questions as to its relation with the Bengal famine. Later documents would note that his services were obtained "Following the disastrous famine in Bengal in 1943" see J. Thomson, Commonwealth Relations Office to B.J Ellis, Ministry of Fuel and Power, 10th December 1946, in British Library (BL) file IOR/L/E/8/5515. There is however, no direct evidence that the Bengal famine is what prompted Stampe to write to the Secretary of State, or that it was the reason for his appointment, as Bengal's food situation was not quite clear until the middle of that year, though the All-India situation was serious enough for a Department of Food to be constituted in December 1942; see Henry Knight, *Food Administration in India 1939-1947* (Stanford, Ca, 1954), pp.57-66. Nevertheless, Bengal and Bihar is where Stampe first offered advice on his arrival in India, see Note dated 28th June 1943, in NAI file: National Defence Council-Irrigation Projects-Points raised by Raja of Bobbili for consideration-Note by Sir William Stampe, I.A. on water versus coal. Stampe would later write of the Bengal famine as the point when provinces other than UP

was probably a means of combating what he later called “the process of human erosion” due to the loss of much knowledge resulting from compulsory retirement policies in the Indian service.<sup>67</sup> He felt he had much to contribute as he saw irrigation as a solution to India’s wartime and postwar food problem.<sup>68</sup> He however felt that large gravity canal systems could not be completed for decades, and millions would have to starve in the meanwhile for lack of foreign exchange. During the war, issues of material and labour shortage would preclude any real progress towards large canal systems, and in the postwar years, the cost of labour would go up (as it was related to food prices), making such schemes expensive. Having previously put under irrigation over 600,000 acres in about four years using tubewells in the Ganges Valley, to him the irrigation technology appropriate for meeting war time food needs and carrying out postwar reconstruction, was not to be large-scale canal irrigation systems but irrigation from tubewells and river pumps on low lying rivers.<sup>69</sup> He discussed the question of wartime irrigation by cable with the Middle East Supply Centre in Cairo and with Sir Bernard Bourdillon the Governor of Nigeria on his way to India, convinced of the wartime importance and global applicability of tubewell technology,

[The] production problems in certain colonies and in the Middle East are similar *mutatis mutandis* to those under review in India... In fact the whole question is one of definite “war” interest as well as of postwar importance.<sup>70</sup>

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began to think seriously about adopting tubewells, see William Stampe, “Memorandum dated 24th December 1948 of a talk with Lord Bruce on 16th December 1948”, undated, in British Library file IOR/L/E/8/7431.

<sup>67</sup> William Stampe, “The Himalayan Dream” An address to the East India Association“, 17 December 1946, copy in British Library file IOR/L/E/8/5515.

<sup>68</sup> As he wrote repeatedly, “It is an established fact that the yield of food and other commercial crops can be increased by as much as 60-100% by means of systematic irrigation in areas of uncertain rainfall.” See for example, William Stampe, “Memorandum dated 24th December 1948 of a talk with Lord Bruce on 16th December 1948“, in British Library file IOR/L/E/8/7431.

<sup>69</sup> William Stampe, *“Planning for plenty”: an address to the Institution of Engineers (India) on November 10th, 1944* (New Delhi, 1944).

<sup>70</sup> William Stampe, “Emergency Irrigation Projects in India. Memorandum dated 25<sup>th</sup> May 1943 on suggested procedure for his Indian tour, by F/Lt. Sir William Stampe, C.I.E, Irrigation Adviser to Government of India”, 25 May 1943, in NAI file: Question of Availing Sir William Stampe’s services in connection with emergency irrigation works in States.

Having decided that tubewells would be the solution to India's food problem, before leaving London he discussed the problem of supplying materials for boring and equipping tubewells in wartime with British manufacturers. Besides finding possible suppliers, he came up with some interesting ideas for supplying machinery such as utilizing the fortuitously available pumps for tubewells due to the curtailment of the fire service in England which utilized near identical pumps, and the use of reserve engines available with the air force in India to power generators and energize tubewells close to airfields. To mitigate the problem of hoarding of food, he proposed taking payment for irrigation water in wheat, and proposed that the same system be used for other inputs such as fertilizers, as it would be a pity to spend public money on irrigation if it was merely to result "in the cultivators growing still more grain and then holding on to it whilst the towns went hungry".<sup>71</sup>

Besides dealing with these issues, he had to raise the prestige associated with tubewells amongst the irrigation bureaucracy. Classified as "minor irrigation", tubewells seemed to have little exciting to offer to the average canal engineer. In a revision of his very first memo, he suggested that the word "emergency" be substituted for the word "minor" in all files,

In view of the effect of the word "minor" on the mentality of the personnel concerned.... Whereas "emergency" connotes the need for dynamic action, "minor" suggests works of a more trivial nature on which the maximum effort is not so likely to be exerted.<sup>72</sup>

Speed being the essence of the problem, Stampe proposed to use aeroplanes for reconnaissance; this would also have the "psychological value of stimulating our local staff to the degree of enthusiasm required for tackling emergency measures" and

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<sup>71</sup> William Stampe, "Emergency Irrigation Projects in India. Memorandum dated 25<sup>th</sup> May 1943 on suggested procedure for his Indian tour, by F/Lt. Sir William Stampe, C.I.E, Irrigation Adviser to Government of India", 25 May 1943, in NAI file: Question of Availing Sir William Stampe's services in connection with emergency irrigation works in States. Stampe had experimented with selling fertilizer dissolved in tubewell water in the Ganges Valley.

<sup>72</sup> William Stampe, "Emergency Irrigation Projects in India. Memorandum of suggested procedure (As revised in September 1943)", September, 1943, in NAI file: Question of Availing Sir William Stampe's services in connection with emergency irrigation works in States.

reconnaissance photographs taken could be used to illustrate reports. This request was granted and much communication during his tenure was about the availability of appropriate landing sites for his aircraft.<sup>73</sup>

The period of the Second World War saw the birth of India's first national food policy, the setting up of the central government's Department of Food, as well as the Grow More Food programme which lasted into the late 1950s.<sup>74</sup> Stampe's appointment predated these steps and represented a bold step by the Government of India, for the construction and management of irrigation was a provincial subject under the Government of India Act of 1935. While much of that act had been suspended for the duration of the war, the creation of a new federal office emphasizes the importance placed by the central government on irrigation as a means of stimulating food production during the war.

While the appointment was of an *ad hoc* nature and his initial remit was to merely make his advice available to any province which desired it with the central government assisting provincial projects with priority for machinery and materials,<sup>75</sup> this remit was to grow as I shall relate. That the appointed adviser was Sir William Stampe, an expert on tubewells, and not, say an engineer from Punjab, which was considered to be at the cutting edge in canal irrigation demonstrates that the colonial administrators were convinced that tubewells could yield quick results during the war.

That wartime urgency was crucial in putting tubewells on the central government agenda is illustrated by an incident soon after Stampe's arrival in India. The Raja of Bobbili wrote a note advocating the construction of large canal irrigation projects on the lines of the great schemes of the nineteenth century. The Raja's demand that his note be circulated for discussion at the National Defense Council created some anxiety among the colonial

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<sup>73</sup> William Stampe, "Emergency Irrigation Projects in India. Memorandum dated 25<sup>th</sup> May 1943 on suggested procedure for his Indian tour, by F/Lt. Sir William Stampe, C.I.E, Irrigation Adviser to Government of India", 25 May 1943, n NAI file: Question of Availing Sir William Stampe's services in connection with emergency irrigation works in States.

<sup>74</sup> R. N. Chopra, *Food Policy in India: A Survey* (New Delhi, 1988).

<sup>75</sup> Jogender Singh (Member for Education, Health and Lands) to all Advisers/Ministers of Governors' Provinces, 14 June 1943, in NAI file: Question of Availing Sir William Stampe's services in connection with emergency irrigation works in States.



bureaucracy and their response tells us much about the background to William Stampe's appointment,

Long Range policy is under consideration in connection with the post-war reconstruction. At present we are vitally interested in growing more food... the necessity for more food transcends ordinary economic considerations. Moreover, conditions after the war may be altogether different from conditions at present... In our opinion therefore, it would be a wrong policy to promote long-term projects at the expense of short term projects... As for irrigation projects, we encourage those which afford promise of quick results. Long-term projects, apart from the difficulty of obtaining raw materials and expert personnel without diverting them from more essential war production will be of no use to us for increasing food production during the present emergency.... The urgent food problem at the moment- the problem with which we have our hands full- is a war problem- how to produce an increased supply of food in the shortest possible time, indeed, immediately... At the moment, what we require is quick return from schemes of a kind that can be carried out in the shortest time with the labour and material available. It is true that these may have no long lasting benefit in some cases though we are trying, especially in the case of Sir William Stampe's proposals to fit our emergency irrigation schemes into plans for long-term projects.<sup>76</sup>

The colonial bureaucracy then, was primarily interested in what it saw as an urgent problem of wartime food production. By the time of Stampe's arrival in India in late May 1943 however, it had become clear that India's food crisis was overwhelmingly one of rice in Bengal,<sup>77</sup> and by his own admission, he was "out of his depth" when it came to rice-growing areas.<sup>78</sup> Tubewells had previously been judged too expensive for rice cultivation.<sup>79</sup> Bengal and Bihar would nevertheless be the first provinces to seek his

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<sup>76</sup> Note dated 18th June 1943, in NAI file: National Defence Council-Irrigation Projects-Points raised by Raja of Bobbili for consideration-Note by Sir William Stampe, I.A. on water versus coal. This note, authored by a Deputy Secretary in the Department of Education, Health and Lands was based the oral opinion of R.A. Gopalaswami, the Secretary.

<sup>77</sup> Knight, *Food Administration*, pp.57-66.

<sup>78</sup> William Stampe, *Planning for plenty* (New Delhi, 1944).

<sup>79</sup> William Stampe, *The Ganges Valley State Tube-well Irrigation Scheme*, p. 13.

advice, though early attempts at tubewell irrigation in those provinces would be met with frustration as the hand boring methods used to drill the Ganges Valley tubewells were inappropriate for the harder strata encountered in eastern India.<sup>80</sup> The larger and more successful projects he advised on would be in wheat growing areas and bore fruit only after the war. However, as I shall relate, his advice, ostensibly for the war, was also a long-term vision for tubewells and for rural development in India.

### **The Himalayan Dream**

Soon after his arrival in India Stampe prepared a memo in June 1943 for discussion in the National Defense Council in case the Raja's memo was referred to. In it, Stampe lamented the lack of appreciation for small-scale power plants,

It seems doubtful whether the importance of water [power]-even on "low head" falls is even now appreciated at its real value... due to the warped commercial angle from which most "large scale" civil engineers have hitherto looked at the problem... How often has one heard it said in the good old peace days-'the head is too low to be economic' of 'the distance is too great to the industrial field followed by "put in a steam station!"<sup>81</sup>

He went on to give the example of the Ganges grid as an exemplar of the "real value of local water power", as it powered tubewells and river pumps which had irrigated a million acres in 1942-43 and produced 400,000 additional tons of wheat.<sup>82</sup> A coal-fired power station would have required 5000 wagon trips a year to produce the same amount of power; hence on the Ganges grid, "human hunger had been met by local water power rather than making inroads on the limited wagon resources of India".<sup>83</sup> Using this

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<sup>80</sup> William Stampe, "Memorandum dated 24th December 1948 of a talk with Lord Bruce on 16th December 1948", 24<sup>th</sup> December 1948, in British Library file IOR/L/E/8/7431.

<sup>81</sup> William Stampe, "Water vs. Coal. A comparison in transport and manpower. Memo for the Defence Council July 3rd 1943", July 3 1943, in NAI file: National Defence Council-Irrigation Projects-Points raised by Raja of Bobbili for consideration-Note by Sir William Stampe, I.A. on water versus coal.

<sup>82</sup> William Stampe, "Water vs. Coal. A comparison in transport and manpower. Memo for the Defence Council July 3rd 1943", July 3 1943, in NAI file: National Defence Council-Irrigation Projects-Points raised by Raja of Bobbili for consideration-Note by Sir William Stampe, I.A. on water versus coal.

<sup>83</sup> William Stampe, "Water vs. Coal. A comparison in transport and manpower. Memo for the Defence Council July 3rd 1943", July 3 1943, in NAI file: National Defence

example, he made the case for importing power plants for harnessing the falls on the Eastern Jumna Canal, the Sharda Canal and the Sone Canal to irrigate additional land with tubewells and produce wheat locally; from the point of view of shipping, this was preferable to importing wheat. He emphasized that while these were small-scale activities, they could be carried out in wartime;<sup>84</sup> the solution to India's wartime food problem that Sir William championed was based on the local and the small.

However, Stampe's long-term vision could hardly be described as small. According to him, under the Indo-Gangetic plains lay vast aquifers whose waters were flowing very slowly under the effect of gravity towards the Bay of Bengal. To him this was the Saraswati river of Hindu mythology,<sup>85</sup> flowing "through the dark sands, unconscious of administrative boundaries, racial difficulties, political differences and 'salutes', only hoping perhaps, as we do to 'surface' and see the dawn of a brighter day."<sup>86</sup> This river could be the source of all the water required for agriculture and was to be a "vital asset" in his plan for India's postwar development.<sup>87</sup> That plan, which he called the Himalayan Dream, envisaged the harnessing of the Himalayan rivers with massive power plants and was described by him in the manner of a battle,

The occasion, too, seems fitting when just as the last bomb thud of the most destructive conflict in human history is shortly to be heard in the west there should be sounding in the east the clear call to this constructive campaign about to open on our dusty plains. I refer to the coming fight with Himalayan forces which must be subdued in order to link these great reserves of mountain power with water which is either seeping silently below the sands of the great plains or flowing

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Council-Irrigation Projects-Points raised by Raja of Bobbili for consideration-Note by Sir William Stampe, I.A. on water versus coal.

<sup>84</sup> William Stampe, "Water vs. Coal. A comparison in transport and manpower. Memo for the Defence Council July 3rd 1943", July 3 1943, in NAI file: National Defence Council-Irrigation Projects-Points raised by Raja of Bobbili for consideration-Note by Sir William Stampe, I.A. on water versus coal.

<sup>85</sup> William Stampe, *Planning for plenty* (New Delhi, 1944).

<sup>86</sup> William Stampe, "Central Groundwater Section: Note on the organisation necessary to implement an all-India Tubewell Irrigation Programme", 17-29 April 1946, in NAI file: Irrigation Projects in the States.

<sup>87</sup> William Stampe, *Planning for plenty* (New Delhi, 1944).

down deep-set rivers at too low a level to relieve the cultivator and his tired cattle in the fields.<sup>88</sup>

The harnessing of Himalayan rivers, like the building of large gravity flow irrigation systems, would require time and experience. In the meanwhile, power for tubewell irrigation was to be supplied by a scheme of “nursery power plants”, a concept pioneered in India by the Electrical Commissioner H.M. Matthews. Small thermal power plants (coal fired for the larger networks and diesel fired for the smaller ones) together with a local transmission network were to energize small groups of tubewells, between ten and hundred in number. Such schemes had been started previously by Stampe in Baroda and Kolhapur. With the availability of a base load in the form of tubewell pumping, cheap power could be made available for cottage industries such as flour and rice milling and oilseed crushing in the countryside. The nursery power plants were to be gradually absorbed into the networks of larger coal fired power plants which themselves were to be subsumed into hydro-electric networks which were “bound to eventuate” as the Himalayan dream took shape.<sup>89</sup>

What may we make of the attitudes to scale of someone who extolled the virtues of “local water power”, while at the same time envisioning the transformation of a vast landscape by large hydroelectric networks? One may surmise that he believed in experimentation and gradualism and in the scaling up of schemes once they proved successful, unlike the caricature of colonial engineers who could only think big. Even as he advocated a campaign to build large dams in the Himalayas, the self-described oldest irrigation engineer in India who “had spent 36 years living on the banks of Mother Ganga”, cautioned his juniors of the perils of intervening in natural hydraulic regimes,

I shall presume ... to offer a word of caution to those enterprising engineers of the Punjab who propose to subdue certain Himalayan tigers by a frontal attack on their main lairs. Personally in my limited experience I have always regarded discretion in *shikar* as the better part of valor. In view of (a) the geological

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<sup>88</sup> William Stampe, *Planning for plenty* (New Delhi, 1944).

<sup>89</sup> William Stampe, “Central Groundwater Section :Note on the organisation necessary to implement an all-India Tubewell Irrigation Programme”, 17-29 April 1946, in NAI file: Irrigation Projects in the States. By 1946, nursery schemes had been sanctioned in Gorakhpur and in Western UP and were under examination in Bengal, Orissa, Patiala, Jaipur, Palanpur, Nawanagar, Sindh and Bahawalpur.

instability of the Himalayan set-up, (b) the technical difficulty and danger of dropping stupendous floods on to the unstable river beds, and (c) the appalling consequences that would follow a failure, would not such planners do well to adopt Mr. Watal's 'appeasement' policy of 'catching the cubs first,' i.e., damming the bigger tributaries and thus gaining experience before tackling the tigress herself. However, as my more daring friends have engaged an international tiger tamer, I must leave it at that.<sup>90</sup>

### **Organizing for Groundwater**

In the process of advising on small emergency irrigation projects in UP, Baroda and the North Western Frontier Province, Stampe felt that provincial efforts were being frustrated by a lack of technical knowledge of the subsoil strata, a lack of technicians and contractors, the difficulty of obtaining equipment, and the high cost and delay in procurement from abroad due to the war. In January 1944, he proposed that a Sub-Soil Water Section be set up in the Department of Agriculture with a nucleus staff to coordinate data, advice the provinces and to carry out trial borings; this was accepted by the department and the provinces were informed of the same in early December. After Stampe's retirement, the organisation was to be merged with the newly set up Central Waterways, Irrigation and Navigation Commission (CWINC).<sup>91</sup>

However, the methods of hand percussion boring which had been used in the alluvium of the Indo-Gangetic plain apparently proved slow and expensive on the harder strata encountered in regions such as central Bihar, Rajputana, Kathiawar and Kutch. To procure more "scientific and expeditious machinery", William Stampe and K.D. Sanwal, a UP engineer deputed as his technical assistant toured North Africa, the UK and the USA where they studied mechanical boring and consulted manufacturers on the adaptation of

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<sup>90</sup> William Stampe, *Planning for plenty* (New Delhi, 1944). A.P. Watal was a senior engineer in UP. "International tiger tamer" may refer to any number of American hydraulic engineers serving in India, perhaps to the American John Savage who had worked on the TVA and was in attendance when Stampe delivered this address to the Institution of Engineers (India) on November 10th 1944.

<sup>91</sup> Sir Pheroze Kharegat, Additional Secretary, Department of Education, Health and Lands to all Provincial Governments, 6 December 1944, in NAI file: Delegation of powers to the Chairman, CGWO.

boring plant to the hard strata encountered in India.<sup>92</sup> In America, they studied drilling equipment in use in California, around the Grand Coulee dam in Washington, the Boise Payette project in Idaho, the Buffalo Rapids project in Indiana and the Klamath project in Oregon, besides visiting O.M. Meinzer's groundwater research laboratory at the United States Geological Survey.<sup>93</sup> Stampe procured eight Ruston Bucyrus drilling rigs from the UK and three rotary drilling rigs from the United States. In addition, he invited Roscoe Moss, a Californian contractor and manufacturer of groundwater equipment to visit India and offer advice on tubewell development.<sup>94</sup>

Roscoe Moss surveyed large parts of northern, eastern and western India by low-level flying in early 1946. He studied existing tubewell practices and recommended that the practice of filling the annular space between the screen and the borehole with gravel be extended to protect against the pumping of sand and to protect the walls of the bore hole from collapse. He recommended gravel shrouded tubewells drilled using rotary rigs that Stampe had procured. These did not require casing pipes for drilling, and, having a thicker gravel protection than was improvised in earlier screen wells, they could be operated with lower cost screens, enabling the consequent use of a larger screen area to increase yields; a method which an impressed Stampe called the Roscoe Moss technique.<sup>95</sup>

After his travels in America, Stampe set down seriously to set up a Central Groundwater Section capable of launching an all India tubewell irrigation campaign and eventually realize the Himalayan dream. At a meeting in January 1946 between the Department of

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<sup>92</sup> William Stampe, "Supplement to Foreword" in K.D. Sanwal, *Handbook on tube-wells* (New Delhi, 1945), p. iv. This book appears to have been a textbook of sort for tubewell development in the 1950s.

<sup>93</sup> Anon., "Foreign Advisers to Inspect Dam", *Spokane Daily Chronicle*, 14 August 1945. Also William Stampe, "'The Himalayan Dream' An address to the East India Association", 17 December 1946, copy in British Library file IOR/L/E/8/5515. For an overview of Meinzer's career at the USGS, see George B. Maxey, "The Meinzer era of U.S. Hydrogeology 1910-1940", *Journal of Hydrology* (1979) 43:1-6

<sup>94</sup> William Stampe, "Central Groundwater Section: Note on the organisation necessary to implement an all-India Tubewell Irrigation Programme", 17-29 April 1946, in NAI file: Irrigation Projects in the States.

<sup>95</sup> Roscoe Moss, "A brief review of ground-water potentialities and tube-well technique in Northern India", 19 Mar, 1946, in NAI file: Delegation of powers to the Chairman, CGWO. Also see William Stampe, "Central Groundwater Section: Note on the organisation necessary to implement an all-India Tubewell Irrigation Programme", 17-29 April 1946, in NAI file: Irrigation Projects in the States.

Agriculture, the Geological Survey of India and the newly set up Central Waterways, Irrigation and Navigation Commission (CWINC), it was agreed that an organisation be set up which would eventually be merged with the CWINC; while the CWINC would take over research and statistics, the Department of Agriculture would continue to oversee the actual development of groundwater resources.<sup>96</sup> However, after Roscoe Moss's visit, Stampe felt that this was not enough, and in April 1946 he proposed the setting up of a permanent quasi-independent organisation called the Central Groundwater Organisation (CGWO), on the lines of the CWINC or the Central Technical Power Board to develop India's groundwater resources. It was to employ engineers and geologists and have all the necessary equipment to drill wells for demonstration, as well as to assist the provinces in their plans. "Give us the tools" Sir William wrote, "and we will finish the job".<sup>97</sup>

Despite some hiccups,<sup>98</sup> the CGWO was soon constituted, though it had much teething trouble, in large part due to Stampe's departure from India due to illness in August 1946 even as the reorganization was being implemented.<sup>99</sup> Among the developments that did take shape before Stampe's departure was a Central Drilling School that was set up in the village of Dhanauri close to Roorkee to train drillers and drilling engineers on mechanical boring methods on the few Ruston Bucyrus and Rotary rigs obtained by the CGWO.<sup>100</sup> About a hundred personnel were trained by the school by 1949, when the CGWO was closed down, in large part because it was felt that the investment on equipment was not

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<sup>96</sup> "Minutes of the meeting held on 25/1/46 to consider the constitution and functions of the Central Groundwater Section as proposed by the committee convened by the I.A. on the 18th & 19th January, 1946 and summarised in the I.A.'s note of 23rd January, 1946", in NAI file: Delegation of powers to the Chairman, CGWO.

<sup>97</sup> William Stampe, "Central Groundwater Section :Note on the organisation necessary to implement an all-India Tubewell Irrigation Programme", 17-29 April 1946, in NAI file: Irrigation Projects in the States.

<sup>98</sup> Evidence for this exists in a letter Stampe wrote, alluding to differences regarding the reorganisation, and saying, "I have made it clear that unless these proposals are accepted, the staff sanctioned and accommodation allotted, I can no longer be responsible for advising on emergency irrigation in India. I have also informed H.E. the Viceroy orally of the position.", see William Stampe to Lt. Col. Sir Cyril Hancock, 5 June 5 1946, in NAI file: Irrigation Projects in the States.

<sup>99</sup> K.D. Sanwal, Note dated 16August 1946, in NAI File: Trans-Gogra Tubewell Irrigation scheme.

<sup>100</sup> Central Drilling School, "Prospectus", 1946, in NAI File: Central Drilling School of the Central Groundwater Section.

commensurate with results.<sup>101</sup> Despite the closure of the formal organisation, the enthusiasm for tubewells that Stampe had kindled within the Department of Agriculture was to remain, and the Department would continue to be the nodal central government department for tubewell development in the coming decades.

### **Righting the wrongs of canal irrigation: The Electrical Federation of India**

The saturation of soil with water to the extent that it becomes unfit for agriculture is termed as waterlogging. According to Sir William, in the “Indian Engineer’s sense”, waterlogging was a phenomenon closely allied to irrigation and defined it as the rise in the water table to the extent that absorption of superfluous surface water into the ground no longer took place. In the absence of adequate surface drainage, water accumulated on the land at a rate greater than evaporation or transpiration by standing crops.<sup>102</sup>

In early 1944, William Stampe was requested by the Premier and the Revenue Minister of the Punjab to bring the serious nature of the waterlogging problem to the notice of the central government. While the long-term problems of large-scale irrigation systems were outside Stampe’s remit, he wrote a couple of memos to the central government on the grounds that “a long-term calamity such as water logging” had a short term bearing on the Grow More Food programme and on emergency irrigation. He noted that 50,000 acres of land was going out of cultivation annually in the Ravi Jhelum tract due to waterlogging and that this was a “very grave menace” threatening the “granary of India.” As “someone who had seen something of India’s irrigation problems lately” he saw it as the “gravest danger facing India’s food supplies.” Unless urgent steps were taken, “The great canal systems will turn against the cultivators of the Punjab-and against India at large-like the Punic elephants of old.”<sup>103</sup> William Stampe saw four possible solutions to waterlogging: to reduce the flow of irrigation water, to improve surface drainage, to line the main canals to reduce absorption losses, and to pump water out of the sub-soil reservoir on a large

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<sup>101</sup> “Tubewell Construction”, in NAI file: Loan from the International Bank for Land Reclamation and Tubewell Construction.

<sup>102</sup> William Stampe, “Emergency Irrigation-Punjab. Rasul Hydel Tube-well pumping project (For de-waterlogging and extending irrigation)”, 31 August 1944, in NAI file: Rasul Hydel Tubewell Pumping Project- For the Punjab Emergency Irrigation Scheme.

<sup>103</sup> William Stampe, “Emergency Irrigation-Punjab. Rasul Hydel Tube-well pumping project (For de-waterlogging and extending irrigation)”, 31 August 1944, in NAI file: Rasul Hydel Tubewell Pumping Project- For the Punjab Emergency Irrigation Scheme.



scale. Stampe recognized that a reduction in the depth of the water applied to the crops to a level “even below the requirement for maximum crop yield” might be better than “to prejudice vast areas of cultivation by applying more water than the local soil could absorb” and recommended “every possible economy” in the distribution and use of canal water. However, as might be expected of an irrigation engineer, he saw the reduction of irrigated acreage as a largely negative solution which should be adopted only when all other options failed. Lining the canals would be too expensive as it would involve the digging of “duplicate canals” while the lining work was in progress. However, even as he dismissed lining as too expensive, Sir William admitted that the solution to waterlogging necessarily lay in “expensive large scale remedies.”<sup>104</sup>

F.F Haigh, a Punjab irrigation engineer had submitted a proposal on the lines of the fourth solution, i.e. large-scale pumping of subsoil water. The project envisaged dropping water from the Upper Jhelum canal into the lower Jhelum canal at Rasul and harnessing the fall using two 11,000 kilowatt alternators. These were to provide power to 2050 tubewells each having a capacity of 2-cusecs. The tubewells to be sited along all channels of the Lower Jhelum, the Upper Chenab and the Lower Chenab canal systems with a capacity of more than 1,000 cusecs where the water table was within 10 feet below the surface. About 4000 cusecs would thus be pumped out from the soil and into the canals, to roughly balance the total seepage from the canals and to irrigate an additional 750,000 acres. While the additional irrigated acres would increase food production, Haigh emphasized that it was “from the point of view of water logging that the project would be of most value”. In addition to the tubewells, power was to be supplied to small towns and villages, as well as the larger towns of Sargodha, Jhelum, Gujrat, Wazirabad, Gujranwala and Hafizabad.<sup>105</sup>

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<sup>104</sup> William Stampe, “Emergency Irrigation-Punjab. Rasul Hydel Tube-well pumping project (For de-waterlogging and extending irrigation)”, 31 August 1944, in NAI file: Rasul Hydel Tubewell Pumping Project- For the Punjab Emergency Irrigation Scheme.

<sup>105</sup> F. F. Haigh to William Stampe, 26 August 1944, in NAI file: Rasul Hydel Tubewell Pumping Project. For the Punjab Emergency Irrigation Scheme. Some power in the initial stages of the project was to be taken from the Uhl hydroelectric system. The area irrigated was to be 1,120,000 acres; with a 33% margin, 750,000 acres could be taken as the safe capacity of the system. While Stampe mentioned as the solution the reduction in the discharge of the canal equivalent to the water pumped from tubewells, so as to reduce the total water entering the system, it may be speculated that increasing the area irrigated would prove to be only a limited measure to control waterlogging.

A power project executed by an irrigation bureaucracy which generated power from existing irrigation canals primarily to energize state-owned tubewells in the countryside, with towns being only a secondary concern could not but have been inspired by the Ganges grid. As William Stampe put it, Haigh had “gone one better” than him by securing the larger drop between two adjacent canals, thereby vastly cheapening the cost of power; but the scheme itself was similar to what was carried out in UP under himself. Yet, in his initial examination of Haigh’s proposal in March 1944, Sir William was skeptical about the possibilities of “strategic results” by the use of tubewells. In his opinion, an individual tubewell was limited in its ability to reduce the water table over a large area; Stampe was unable to reconcile the idea of using tubewells to lower the water table in the Punjab with his opinion that tubewells would not lower the water table in the Ganges valley. Instead, to solve the waterlogging problem, he favored a system of “pumped drainage” consisting of deep arterial drains leading the surface run-off to the canal banks from where the water would be pumped back into the main canal. While not entirely dismissive of Haigh’s tubewell proposal, Stampe advised that at the very least pumped drainage also be tried out on a small scale; in fact he recommended that all the solutions be experimented with.<sup>106</sup>

By late August 1944 however, following a discussion with Haigh, Stampe changed his opinion on tubewells as a possible solution to waterlogging in Punjab. According to him, UP’s state tubewells did not lower the water table as the hours of pumping and the number of tubewells had been deliberately restricted in UP for precisely that purpose. Also, the subsoil water flowed away freely in the underground aquifer in UP. In Punjab on the other hand, it had been long speculated that the free flow of groundwater was restricted due to an impervious underground ridge, perhaps an extension of the Delhi ridge. In fact, in 1939-40, Stampe had declared tubewells unsuitable for use in Rajputana as the region was cut off from the Punjab alluvium by the ridge.<sup>107</sup> Due to the impervious ridge,

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<sup>106</sup> William Stampe, “Emergency Irrigation-Punjab. Rasul Hydel Tube-well pumping project (For de-waterlogging and extending irrigation)”, 31 August 1944, in NAI file: Rasul Hydel Tubewell Pumping Project- For the Punjab Emergency Irrigation Scheme.

<sup>107</sup> Committee of Enquiry into the possibility of improving the underground water supplies of Marwar, *Report on the proceedings and findings by Sir William Stampe and the members of the Committee 1939-40* (Jodhpur, 1940) as quoted in J.B.Auden, *Introductory Report on the Ground-Water Resources of Western Rajasthan* (Calcutta, 1950), p. 19-20. The existence of this ridge had been indicated by pendulum observation by the Geological Survey of India and later by an analysis of oil exploration data by the

Punjab's subsoil reservoir had only an inflow and no outflow; hence if a minimum rather than a maximum pumping rate was set, tubewells would indeed help lower the water table. Stampe still felt that an "area" treatment based on a system of deep drains and pumps would work better than a linear treatment based on tubewells lining the main canals, but saw value in Haigh's plan for gradual development over four years as it would enable experimentation with all the possible solutions. Stampe recommended that the highest priorities be granted to the project and an official be deputed to visit the UK to coordinate matters with the appropriate staff.<sup>108</sup>

The possibility of using minor irrigation systems such as tubewells and pumps to fix the lacunae of large canal irrigation systems was no doubt one of the reasons William Stampe chose to go beyond his beat and champion solutions to Punjab's waterlogging problem. Stampe promoted the scheme as the first step in his proposed "Electrical Federation of India", which was no run-of-the-mill national grid. This plan envisaged harnessing the major rivers and using the power therefrom for tubewells and river pumping schemes; stable base load thus secured, cheap power could be provided for running cottage industries.<sup>109</sup> Unlike the urban-industrial vision for electricity of nationalist planners,<sup>110</sup> it was a recognition of the agricultural and the rural as central to India's future; these were not part of a supplementary plan for the new technology.

The Rasul scheme became the Punjab's first major postwar reconstruction scheme and its foundation stone was laid in November 1946.<sup>111</sup> Lying in what became Pakistani territory,

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Burmah Oil Company at the request of J.N. Mukherjee, the director of the Indian Agricultural Research Institute. See J.N. Mukherjee to P.M. Kharegat, 19 October 1946, in NAI file: Groundwater Investigation in Punjab by the Burmah Oil Company.

<sup>108</sup> William Stampe, "Emergency Irrigation-Punjab. Rasul Hydel Tube-well pumping project (For de-waterlogging and extending irrigation)", 31 August 1944, in NAI file: Rasul Hydel Tubewell Pumping Project. For the Punjab Emergency Irrigation Scheme.

<sup>109</sup> Anon., "Post-war planning and development in India", *International Labour Review* 52 (1945), p. 53.

<sup>110</sup> For example, the urban-industrial vision expressed in K. T. Shah, *Power and Fuel*, which I previously contrasted with Stampe's vision in Kapil Subramanian, "Canals, Sugarcane and Tube-wells: System Building in an Agrarian Economy", (unpublished masters dissertation, Imperial College, London, 2011).

<sup>111</sup> Anon., "Rasul Hydroelectric Project: Punjab's First Major Post-War Reconstruction Scheme", *Times of India*, 28 November 1946. The number of tubewells planned was reduced slightly to 1800.

for several years it was the largest hydroelectric installation in that country. Postcolonial priorities were however slightly different; only 1373 tubewells were in use by 1955 as power had to be diverted “to more urgent industrial work”.<sup>112</sup> Nevertheless, the fact that the largest power plant in the country was closely associated with tubewell irrigation, together with the fact that waterlogging was more severe in Pakistan than in India may well have been among the reasons that Pakistan took to tubewell irrigation in a big way some years before India did. Tubewells would be central to Pakistan’s anti-waterlogging programmes and the Rasul project would be the precursor to larger schemes carried out as Salinity Control and Reclamation Projects (SCARP) with funding from USAID and the World Bank.

### Conclusion

At the turn of the twentieth century, the India Irrigation Commission placed much emphasis on private wells as a means to increase India’s irrigated acreage based on the notion that the possibilities of easy and cheap expansion of surface irrigation were close to exhaustion. It gave a fillip to provincial well-boring agencies which began experimenting with assisting in the development of private tubewells on a small scale; most notably in UP. While these experiments proved that tubewells held much promise by the mid-1920s, extension of the technology was limited by its high capital cost which made private tubewells viable for large farms and by the high cost of pumping with oil engines in the absence of a rural power infrastructure.

The Irrigation Branch under William Stampe began a rural-electrification and public tubewell irrigation programme in the late 1920s. Within a decade, UP’s public tubewells were irrigating a significant 600,000 acres, making it the largest organized groundwater irrigation programme anywhere in the world. Besides the pioneering of tubewell irrigation, the Ganges grid was significant in demonstrating the pride that colonial engineers such as William Stampe took in a project consisting of small power stations serving agriculture and rural industry. However, both the Ganges grid’s scale and its vision of electrification fostering a rural-agricultural modernity was ridiculed by nationalist technocrats such as Meghnad Saha who saw electricity as a large-scale, urban-industrial technology. Putting visions of technology and development in sharp contrast,

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<sup>112</sup> James Russel Andrus and Azizali F. Mohammed, *The Economy of Pakistan* (Oxford, 1958), pp. 213& 87.

the story of the Ganges grid argues against the idea that all colonial engineers suffered from gigantism; the Ganges grid was a vision for electricity that would have been more acceptable to Gandhi than the large-scale, urban-industrial vision of dominant nationalist planners.

During the Second World War, the colonial administration was interested in stimulating food production to meet the immediate needs of a wartime economy. As enhanced irrigation facilities were widely seen to be a prerequisite for increasing productivity, an Irrigation Advisor was appointed to the Government of India. That the appointee was the retired engineer Sir William Stampe who was the father of tubewell irrigation in India, rather than a serving canal engineer demonstrates that tubewells, rather than canals were seen to offer quick results in stimulating food production. The sense of wartime urgency was crucial in putting tubewells on the central government agenda. However, while Sir William pushed tubewells as a quick and cheap means to irrigate large acreages in India and serve India's wartime food requirements, his vision for groundwater irrigation was grander. His tenure would have a significant impact on postwar reconstruction and on postcolonial economic development in Indian subcontinent for decades to come as I will show in Chapter 4.

Being a gradualist, Stampe appreciated the value of small and localized schemes as they could serve as experiments that could be scaled up if they proved successful. He saw the vast aquifers below the Northern Indian alluvium as a strategic resource for India's development and his long-term gargantuan vision was to harness the Himalayan rivers to power the extraction of this groundwater. Even as he advocated the building of large hydro-electric power schemes, he was cognizant of the dangers of intervening in Himalayan hydraulic regimes and recommended a policy of learning from smaller schemes before pursuing larger ones. This demonstrates that at least some colonial engineers were aware of the limits to their knowledge and the adverse impact it might have on the local environment.

His awareness of the potential perils of hydraulic engineering was also demonstrated by the priority which he, along with other engineers and colonial-era politicians gave to finding solutions to waterlogging in the Punjab which had been caused by the indiscriminate development of colonial canal irrigation systems. His preferred solutions amounted to solving the problems created by one large-scale, expensive intervention into

the nature by another such intervention. The Rasul scheme of harnessing irrigation canals to power tubewells to lower the water table in the affected areas, which was championed by Sir William became the largest hydro-electric installation in Pakistan as well as a pioneer in both tubewell irrigation and solutions to waterlogging in that country. Based on that scheme, Stampe developed a vision for the role of electricity in India's economic development with agriculture as its very core. In the next chapter, I will show how the interest he had evoked in the central government in the new form of irrigation, as well as his specific plans had lasting impact in postwar India.

### Chapter 3: Planning Irrigation in Nehruvian India

The general view expressed in the works of political scientists is that India invested little in agricultural technology in the Nehruvian era; this argument is best exemplified in the work of Ashutosh Varshney. According to this view, until the mid-1960s, the government of independent India pursued an “institutional strategy” in agriculture whereby higher production would come from measures such as land reforms, community development and cooperatives. After Nehru’s death, this was replaced by a “technocratic strategy” of price incentives and heavy investment in agricultural inputs such as fertilizers and cheap electricity. It is argued that the Nehruvian state massively underinvested in agriculture; investment in dams is dismissed as being merely for power production.<sup>1</sup> In contrast to this argument advanced by political scientists, some historians such as Daniel Klingensmith and Rohan D’Souza have emphasized postwar India’s heavy commitment to big dams. Their essential argument is that late colonial state and the technocratic elite in India fetishized the multipurpose river valley development model of the Tennessee Valley Authority and attempted to use the same to serve their own material, rhetorical and ideological ends.<sup>2</sup>

I will challenge these arguments. I shall argue that India commitment to dams was neither just for power production nor merely in pursuit of the TVA’s rhetorical and ideological example. Irrigation (which the TVA notably did not provide for) was the central concern of water management in Nehruvian India as it had been during the colonial period. Irrigation engineers, who constituted perhaps the Raj’s strongest technical bureaucracy had long wanted to build big dams but had been stymied by the colonial central government’s restrictive public investment policy. A combination of factors, including the perceived exhaustion of the potential for traditional river diversion schemes, the massive funds available for economic development after the war, acute food crises and the rising importance of power production and flood control (which could help compensate for some of the cost of dams) was what led India to invest heavily in dams in

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<sup>1</sup> Ashutosh Varshney, *Democracy, Development, and the Countryside: Urban-Rural Struggles in India* (Cambridge, 1998), p. 41.

<sup>2</sup> Daniel Klingensmith, *One Valley and a Thousand: Dams, Nationalism, and Development* (New Delhi, 2007) studies the TVA and the Damodar Valley Corporation besides providing an overview of the history of dams in independent India. Rohan D’Souza, "Damming the Mahanadi river: The emergence of multi-purpose river valley development in India (1943-46)," *Indian Economic and Social History Review* **40** (2003): 81-105 studies the events leading to the building of the Hirakud dam.

the immediate postwar period. I shall argue that, irrigation was seen as the very basis of technical change in Indian agriculture; one which would enable the cultivator to break free from dependence on the monsoon and incentivize the adoption of multiple cropping, improved seeds, the use of manures and fertilizers and other improved agricultural practices. Irrigation thus accounted for a large share of the outlay on agriculture in all of India's Five Year Plans and independent India saw an impressive growth in its irrigation infrastructure. In keeping with practice of the colonial period, large surface irrigation systems accounted for the lion's share of state investment in irrigation during the 1950s. But as I will show, Nehruvian India also significantly scaled up British efforts at small-scale irrigation; an obsession with the large scale was thus less central to the period than is conventionally assumed.

The political scientists' argument about Nehruvian underinvestment in agriculture is based on an implicit comparison with the period of the "Green Revolution" that followed in the late 1960s and thus fails to emphasize that government spending on agriculture and irrigation in Nehruvian India was massively higher than during the Raj. I will argue that while it was true that the left-elite technocrats in Nehru's Planning Commission may have preferred to neglect agriculture in favour of rapid industrialization, they were unable to prevent provincial governments from undertaking irrigation projects; such was the proliferation of irrigation schemes that resources were stretched thin to the point of crisis by the mid-1950s. The story of irrigation thus shows the weakness of Nehru and the Planning Commission in the face of provincial demands.

From the late 1950s however, public irrigation systems in India started running into serious difficulties which included not just high cost and financial losses but also a failure to utilize the irrigation infrastructure created; as a result planners began to emphasize the prioritization of the full development of existing irrigation projects rather than taking up new ones. But not only did provincial pressures force the central government to continue to commit to new large schemes, they also forced it to adopt a new criteria for sanctioning irrigation projects which was less restrictive, using arguments that went to the heart of what it meant to be a welfare state.

#### **A statistical overview of irrigation in postcolonial India**

Between 1950 and 1980, the net area irrigated in India nearly doubled from 20.8 million hectares to 38.5 million hectares. The area irrigated by tanks saw an absolute decline



during the period as a whole, with a spectacular 37% decline from their peak in 1964-65; the area irrigated from “other sources” also suffered a decline during the period. The growth in irrigation was led by canals and groundwater. The area irrigated by canals increased by an impressive 78% during the period. But by far, the most impressive growth took place in irrigation from groundwater, and the total area irrigated by wells and tubewells tripled during this period (see Table 3.1).

Year	50 - 51	55 - 56	63 - 64	64 - 65	65 - 66	66 - 67	67 - 68	68 - 69	69 - 70	70 - 71	75 - 76	79 - 80	CAGR 50-64	CAGR 64-80
Canals	8	9	11	11	11	11	11	12	12	13	14	15	2.2	1.8
Tubewells			1	1	1	2	2	3	4	4	7	9		
Wells	6	7	7	7	7	7	7	8	7	7	8	9	2.1	6.6
Others	3	2	2	3	2	2	2	2	3	2	2	2	-1.4	-0.1
Tanks	4	4	5	5	4	4	4	4	4	4	4	3	1.9	-1.7
Total	21	23	26	27	26	27	27	29	30	31	35	39	1.7	2.5
Groundwater share (%)	29	30	30	30	33	34	34	37	37	38	42	46		
Canal share (%)	40	41	43	42	42	42	41	41	40	41	40	38		

**Table 3.1: All India net irrigated area from various sources in million hectares 1950-80.**

**Sources and Notes:** Till 1969-70, figures have been taken from Directorate of Economics and Statistics, *Indian Agricultural Statistics, 1960-70* (New Delhi, 1972). For the years 1970-71, figures have been taken from the 1969-72 edition of the same publication. Figures for 1975-76 and 1979-80 are taken from the 20<sup>th</sup> and 22<sup>nd</sup> edition of respectively of Directorate of Economics and Statistics, *Indian Agriculture in Brief* (New Delhi) which rely on the same data set. Before 1960-61, data for tubewells was included in the figure for wells in general, and in that year only Punjab and Pondicherry collected data for tubewells separately. The figure for canals includes private canals which irrigated between 0.8 and 1.4 million hectares in the period. Statistics mentioned in the rest of the chapter are not comparable with this data as unless otherwise stated, they refer to gross rather than net irrigated acreage; the former double counts land irrigated more than once during the year. CAGR= Compounded annual growth rate.

This era may be divided into two phases: before and after 1963-64. The total irrigated area grew at a compounded average of 1.7% per annum during the first period and at 2.5% during the subsequent period. Canals led the growth in irrigation in the first period, contributing over half of the increase in the irrigated area, and their share of the irrigated area which stood at about 40% in 1950-51 peaked at about 43% in 1963-64. The rate of growth of irrigation from groundwater sources, at 2.1% was about the same as that of canals (2.2%) before the mid-1960s. However, in the period 1963-1980, groundwater irrigation grew at a spectacular rate of 6.6%; in comparison, canal irrigation grew at a measly 1.8%, while tanks and other sources were in absolute decline. The contribution of

groundwater to the total irrigated area which stood at 29% in 1950-51, reached near parity with canal systems by 1970 and increased to 46% by 1979-80 and continued to grow in subsequent decades. This increase was spurred by the growth of tubewells which contributed barely 4% of the total irrigated acreage in 1963-64; this rose to 24% in 16 years with the area irrigated by tubewells increasing by eight times. Hence the overall story of irrigation technology in independent India is the growth of canal systems and of groundwater irrigation, with the former leading the growth of irrigation infrastructure until the early 1960s and the latter from the mid-1960s.

### **The rise of storage-based irrigation**

Before the coming of the British, large-scale irrigation systems in India were largely inundation canals. These diverted the flood waters of a river into channels for use in irrigation elsewhere but usually lacked the headworks to divert the normal flow of the river. Colonial intervention in irrigation which began with the repair of these works moved on to the development of *perennial* canals which diverted some of the normal flow of the river into canals for use all year round. While these perennial canals had a spectacular impact in the regions where they were constructed, they were limited in being dependent on the temporal availability of water in the river; not all rivers offered a more or less assured adequate flow with sites where the water could be easily diverted into canals.

From the turn of the century, many saw the next step in irrigation development to be in the storage of water by the building of large dams and reservoirs, particularly in Deccan and peninsular India. But the Irrigation Commission (1901-3) pointed to the technical and financial challenges in reservoir construction and instead recommended a large programme of perennial canal schemes, mostly in Punjab and northern India where potential for the same still existed; this kept the irrigation bureaucracies occupied for the next couple of decades. As an alternative to storage reservoirs, the Irrigation Commission recommended the use of the natural storage available in underground aquifers through private wells as a means to extend irrigation.<sup>3</sup>

The UP tubewell scheme was a notable exception to the extension of diversion schemes. There was also two exceptional cases of dams built in colonial India. In 1924 the

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<sup>3</sup> *Indian Irrigation Commission, Report of the Indian Irrigation Commission* (London, 1903).

engineer-dewan Sir M. Visvesvaraya built the Krishnarajasagar dam on the Cauvery River in the princely state of Mysore as the first multipurpose irrigation and power dam in India; this project notably predated the TVA.<sup>4</sup> The Mettur dam built in Madras a decade later on the same river was the only other notable irrigation dam built in colonial India and also produced power.<sup>5</sup>

By the early 1930s, the last of the great colonial irrigation works had been built,<sup>6</sup> and these were largely based on diversion of surface water. The general pessimism about artificial storage was resented by many irrigation engineers; among them was Nawab Ali Nawaz Jung Bahadur, a Cooper's Hill trained engineer employed by the princely state of Hyderabad. Ali chaired the sub-committee on River training and Irrigation of the Congress Party's National Planning Committee formed in 1938 and his view can be seen to represent those of engineers and nationalists. Jung Bahadur saw storage as the logical culmination of Indian irrigation history which had begun from inundation and moved on to perennial canals; what was needed now was the ability to ensure a year round supply of water independent of the temporal stream flow. His report argued that in its emphasis on wells, the Irrigation Commission had overestimated the potential for irrigation from groundwater; not enough was known about India's aquifers and only under special conditions of "climate, crops and markets" could the high cost of raising water be justified.<sup>7</sup> The focus of the report was on extending irrigation in the arid uplands of central India, where only 10% of the land was irrigated (and only 4% from government canals) as compared to the arid alluvial lands (mostly in northwestern India), where almost 46%

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<sup>4</sup> Henry Hart, *New India's Rivers* (Bombay, 1956), p. 120.

<sup>5</sup> Statistics on number of dams necessitate some elaboration. It is usually accepted by historians that Mettur was the only dam built in British India, see for example Daniel Headrick, *Tentacles of Power: Technology Transfer in the Age of Imperialism 1850-1940* (New York, 1988), p. 182 and Elizabeth Whitcombe, "Irrigation," in Meghnad Desai and Dharma Kumar (eds.), *The Cambridge Economic History of India* (New Delhi, 2005), p. 720. However, the Indian National Register of Large Dams (2014) mentions 373 large dams constructed in India before 1950 and 4846 large dams completed by 2014; this figure is not substantially different from the about 4500 enumerated by the World Commission on Dams (2000) and cited in Klingensmith, *One Valley and a Thousand*, p. 3. However, both of the latter two sources define a large dam as one higher than 15m (10m in special cases). If we take the cut off as a height over 100m (or a storage capacity over 1 cubic kilometre), which the Indian National Register of Large Dams uses to define a "Dam of National Importance," there were only two such dams completed before Independence and 59 completed by 2014.

<sup>6</sup> Whitcombe, "Irrigation," p. 730.

<sup>7</sup> K. T. Shah (ed.), *Report of the Sub-Committee on River Training and Irrigation of the National Planning Committee* (Bombay, 1947), p. 47.

of the land was irrigated (31% from government canals). The extension of surface irrigation to correct this regional imbalance would necessarily require storage in the upland topography that dominated central India.<sup>8</sup>

There remained the issue of the high cost of storage, which was the primary reason the Irrigation Commission had been pessimistic about dams. The criteria for sanctioning irrigation projects was a minimum annual return to the government in the form of water charges within ten years of commencing operations; this was specified at 6% of the capital cost at the time of Jung Bahadur's writing. To him, this rate of return was high enough to be termed "retrograde" and represented "the severest blow to irrigation".<sup>9</sup> It was unfair to compare storage-based irrigation in the upland topography with the works already built in the lowlands; the former was of a "superior class".<sup>10</sup> The report called for a lowering of the rate of return required of irrigation projects.<sup>11</sup>

From the late 1930s to the early 1950s, various factors engendered a favourable landscape for large storage projects, though these were only taken up after the Second World War. With the introduction of provincial autonomy in 1937, most provinces gradually reduced the annual return required of irrigation projects to 4% and in 1949 the rate prescribed by the Government of India was also reduced to 3.75%.<sup>12</sup> The felt need for power and flood control (to which a part of the cost of building storage could be ascribed to) lowered irrigation's share of the cost, making it more likely to meet the government's cost criteria for project sanction.<sup>13</sup> In any case, the postwar developmental state was expected to be less stringent on the cost of projects and there was rising optimism amongst irrigation engineers through the early 1940s about the massive projects that were in offing after the war.<sup>14</sup> The postwar food crisis which placed a considerable strain on India's foreign exchange position, the feeling that it was unfair to subject the more expensive storage schemes to the same criteria as the diversion schemes together with vague ideas about the adoption of a "socialistic pattern of society" meant that the financial productivity test,

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<sup>8</sup> Shah (ed.), *River Training and Irrigation*, pp. 30-53.

<sup>9</sup> Shah (ed.), *River Training and Irrigation*, p. 51.

<sup>10</sup> Shah (ed.), *River Training and Irrigation*, pp. 51.

<sup>11</sup> Shah (ed.), *River Training and Irrigation*, p. 52.

<sup>12</sup> Committee to Suggest Ways & Means of Improving Financial Returns from Irrigation Projects, *Report* (New Delhi, 1964), p. 20.

<sup>13</sup> Planning Commission, *The First Five Year Plan* (New Delhi, 1952), p. 90.

<sup>14</sup> See the Inaugural Speeches in the *Proceedings of the Annual Meeting of the Central Board of Irrigation and Power* (New Delhi, 1943-47).

even at a reduced rate of return was only loosely followed.<sup>15</sup> By the time of the First Five Year Plan which began in 1951, the prevailing criterion for sanctioning projects effectively was “for increasing the production of food and other agricultural produce, it is necessary that irrigation projects should be taken up wherever there are facilities for such projects”. Many projects which failed to meet the financial productivity test were taken up.<sup>16</sup>

Several irrigation projects were sanctioned in the six years between the end of the war and the commencement of the First Five Year Plan. The Central Board of Irrigation and Power (CBIP)’s first popular publication dated 1948 mentioned several projects at various stages of investigation, sanction and progress in the provinces. While the list is not exhaustive and projects were amenable to change (for example, some of the project descriptions seem to suggest that either irrigation or power were added as an afterthought), it provides an interesting snapshot of projects considered important. Of the 55 projects mentioned by name, 45 involved storage of some sort and of the rest, 6 were irrigation-only projects and 4 were power-only projects. Of the 45 projects involving storage, 13 were for power alone, 20 were for irrigation alone while 22 were for both.<sup>17</sup>

There is no doubt that the example of the TVA also served to legitimate big dams. The TVA’s objectives were power production and flood control (that project had no irrigation component) and its influence was particularly felt in eastern India where flood control was at least as important an objective as irrigation; though even there, irrigation was also an objective.<sup>18</sup> But of the hundreds of irrigation schemes that became part of India’s First Five Year Plan, only four (Bhakra Nangal, Harike, Damodar Valley Project and Hirakud dam) were classified as “Multi-Purpose” projects and fit the TVA model of being entirely federally funded;<sup>19</sup> and only the Damodar project was to be built and managed by a corporate entity on the lines of the TVA. The nature of India’s irrigation projects were

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<sup>15</sup> Improving Financial Returns, *Report*, p. 20.

<sup>16</sup> Improving Financial Returns, *Report* pp. 20-21.

<sup>17</sup> Compiled from Central Board of Irrigation and Power, *New Projects for Irrigation and Power* (New Delhi, 1948).

<sup>18</sup> It is not insignificant that both of the existing studies on dams in India are on eastern Indian projects; see Klingensmith, *One Valley and a Thousand* and D’Souza, “Damming the Mahanadi river”

<sup>19</sup> Planning Commission, *Development schemes in the first five year plan* (New Delhi, 1952). Harike is not mentioned in the main text of the Plan. The inclusion of Harike was strange as it does not appear to have a power production component at this stage. Work on the same only began after the Indus Water Treaty of 1960.

indeed changing as the CBIP pamphlet emphasized; but the change was a shift towards building storage structures to utilize the monsoon flows of the rivers to provide perennial irrigation,<sup>20</sup> a long standing ambition of irrigation engineers in India whose fruition could not be reduced to a mere adoption of the TVA model.

### **The Centrality of Irrigation: The First Five Year Plan**

The Planning Commission was set up in 1950 as an advisory body chaired by the Prime Minister to launch a programme of planned economic development. The first five year plan which was launched in 1952 for the period 1951-56 could only have been a statement of ongoing projects, together with a rationale for the same, and comments on long-term policy. In Nehru's own words, "we just took what was there and called it a plan".<sup>21</sup> This was particularly true in the case of irrigation, which was a provincial subject.

The plan made a strong case for increasing irrigation and noted that four fifths of India's land was rainfed with the rains neither timely nor adequate, making frequent crop failures an important feature of the Indian economy.<sup>22</sup> The "outstanding feature" of India's rainfall was its unequal distribution through the year and from year to year; the tropical climate, with no rainfall for much of the year was seen to make successful cultivation impossible in many parts of the country without irrigation. In the absence of irrigation, large areas only produced an often deficient and unevenly distributed crop; low yields were hence not surprising. Further, the cultivator had to restrict himself to particular crops that could be matured during the two or three favourable months. It was expected that irrigation could improve yields between an impressive 50 and a spectacular 300%, besides enabling large areas of wasteland to be brought under the plough. With irrigation, the cultivator could plan a scheme of cropping that kept him busy all year round, leading to increased production and perennial employment; two or even three crops a year were possible under irrigated conditions. As irrigation mitigated the risk of monsoon failure, it would incentivize the farmer to improve cultivation through better seeds and manures, hence transforming the entire agricultural pattern of large parts of the country. This long standing felt need for irrigation was strengthened by the loss of India's best-irrigated lands due to partition; with 18% of the population and 23% of the land of undivided India, Pakistan inherited a little over half of its canal-irrigated area which produced 32% of the

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<sup>20</sup> CBIP *New Projects*, p. 2.

<sup>21</sup> As quoted in Mritunjy Banerjee, *Economic Planning in India* (New Delhi, 1981), p. 23.

<sup>22</sup> Planning Commission, *First FYP*, p. 31.

rice, 35% of the wheat and 25% of all foodgrains.<sup>23</sup> Hence the Planning Commission noted that the most effective way of increasing production was an additional source of water supply through irrigation, which would form the basis of improved agricultural practices such as better seeds, fertilizers and manures.<sup>24</sup> In fact, seen as a basic infrastructure such as roads and power, irrigation was placed at the centre of the transformation of the Indian economy as a whole.<sup>25</sup> Even the Community Development Project, which many have seen as an alternative to technological improvement in Indian agriculture,<sup>26</sup> was to depend on irrigation; the most basic criteria for the selection of an area for Community Development was the existence of irrigation facilities.<sup>27</sup> Over 60% of the target for increased food production was to come from extending irrigation and over 27% of the total outlay in the first plan was devoted to irrigation and power; in addition a substantial portion of the 17% devoted to agriculture and community development was also earmarked for small-scale irrigation.<sup>28</sup>

The centrality of irrigation thus settled, the question of scale and technology remained. Due to the inflexibility of large projects, this choice had been dictated in part by decisions made in the pre-planning era. The Commission was by no means an all-out enthusiast for the large irrigation schemes that had been foisted upon the first plan. It rued the fact that work on many projects had commenced without detailed economic studies and called for periodic reviews. It noted that partly as a result of inflation and as a result of the complexity of storage projects such as high dams, costs had soared; this demanded and recommended a revamp of the revenue structure. The complexity of managing multipurpose river valley projects was also of concern; irrigation, navigation, power generation, flood control and fisheries all had often conflicting schedules for releasing water. The Commission assigned an expenditure of Rs. 5.18 billion for the completion of these ongoing projects, taking pains to emphasize that the commitment did not reflect its views on the merit of the projects, and adding that it had impressed upon the states to prioritize projects which would have an immediate impact on food production and recommended the modification of large projects.<sup>29</sup> In a speech to the Central Board of

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<sup>23</sup> Planning Commission, *First FYP*, p. 93.

<sup>24</sup> Planning Commission, *First FYP*, p. 32.

<sup>25</sup> Planning Commission, *First FYP*, p. 21.

<sup>26</sup> For this view, see Varshney, *Democracy*.

<sup>27</sup> Planning Commission, *First FYP*, p. 49.

<sup>28</sup> Planning Commission, *First FYP*, pp. 11 & 39.

<sup>29</sup> Planning Commission, *First FYP* (New Delhi, 1952), p. 94.

Irrigation and Power, its Deputy Chairman VT Krishnamachari also emphasized the fact that large schemes had been emphasized in the First Plan only because most of them had already been committed to.<sup>30</sup> However, the Commission did commit an additional Rs. 400 million for four new large projects (which would cost a total of Rs. 2 billion) in the last two years of the plans on the grounds that it would help utilize the technical resources that had been built up in the early part of the plan.<sup>31</sup> This total outlay of about Rs. 5.6 billion during the First Five Year Plan may be compared to the Rs. 1.5 billion that represented the *total* capital outlay on irrigation during the colonial period; a figure which had hardly changed since 1932-33.<sup>32</sup> While these figures are not corrected for inflation, the comparison still emphasizes the massively increased emphasis independent India placed on irrigation in comparison to the colonial period.

Besides these larger schemes, the First Plan laid much emphasis on minor irrigation. According to it, small community managed works had several advantages such as dispersed employment, smaller outlay, quicker fruition and the possibilities of greater public cooperation. However, the recovery of water rates was difficult and small irrigation structures often fell into disrepair. The Plan was optimistic about mitigating these problems through taking over of the management of the works by irrigation departments with *panchayats* playing a large role in maintenance and repair. It recommended that each state carry out a systematic survey of the possibilities of minor irrigation and set up a trained corps available to local communities for the execution of these works. Amongst works which were of an individual nature, it recommended a continuing programme of loans and subsidies for well construction.<sup>33</sup>

In monetary terms, it agreed to an initial outlay of Rs. 470 million for minor irrigation; an additional Rs. 300 million for minor irrigation and Rs. 60 million for tubewell construction was later allocated to meet a projected shortfall in the food-production target. In addition, a third of the community development outlay of Rs. 900 million was expected to be spent on minor irrigation,<sup>34</sup> taking the total allocation to about Rs. 1.13 billion,

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<sup>30</sup> V.T. Krishnamachari, "Inaugural Address" in Central Board of Irrigation and Power., *Symposium on determination of costs and benefits of river valley projects 1953* (New Delhi, 1954), p. 3

<sup>31</sup> Planning Commission, *First FYP* (New Delhi, 1952), p. 94.

<sup>32</sup> Whitcombe, "Irrigation," p. 729.

<sup>33</sup> Planning Commission, *First FYP*, p. 33.

<sup>34</sup> Planning Commission, *First FYP*, p. 48.



much larger than the Rs. 400 million it allocated for new major irrigation projects. In addition, some provinces had included minor irrigation in their outlay for major schemes. The plan was expected to bring 19.7 million acres under irrigation, of which about 11.3 million acres were to come from minor irrigation and the rest from major irrigation works. Of the minor-irrigation works, 4.4 million acres were to come from small dams and channels, 6 million from wells, 0.7 million from tubewells not included in the major programme, 0.8 million from tanks, 0.7 million from pumping installations, and 3 million from the additional programme.<sup>35</sup>

From this it is clear that while it is true that Nehru's elite planners invested heavily in large schemes, they were concurrently enthusiastic about small schemes as well. These were to contribute over half of the total increase in the irrigated area; a third of the total irrigation target of the plan was to be met from private wells alone. Nehru himself was an enthusiast for the small-scale irrigation; for example he personally ordered that a committee be set up to investigate a district administrator's advocacy of unlined wells as a cheaper mode of irrigation than large dams.<sup>36</sup> The administrative challenges of managing a large number of dispersed schemes by a largely underdeveloped agricultural development machinery, together with the perception that minor irrigation (assumed to consist of largely open wells and tanks) was more dependent on rainfall (and hence less of an insurance from drought) were the chief reasons dampening that enthusiasm.<sup>37</sup> As I will show in the next chapter, public tubewell programmes formed a substantial part of the outlay on major irrigation schemes in some provinces.

What were the features of the new irrigation projects? Three were large multi-purpose central government projects namely Bhakra Nangal in Punjab, Damodar Valley Corporation in Bengal and Bihar, Hirakud in Orissa. Of the provincial surface irrigation projects, four cost more than Rs. 100 million namely Tungabhadra (Madras and Hyderabad), Bhadra (Mysore), Mayurkashi (Bengal) and Lower Tapi (Bombay). The lower Bhavani Project in Madras and the Ghatprabha project in Bombay cost between Rs. 50 and Rs. 100 million while two projects in Hyderabad, two in Madras, two in Bombay and one in Rajasthan were to cost between Rs. 30 and Rs. 50 million. These were

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<sup>35</sup> Planning Commission, *First FYP*, p. 49.

<sup>36</sup> The Technical Committee on Large-Sized Kutch Irrigation Wells, *Report of The Technical Committee on Large-Sized Kutch Irrigation Wells* (New Delhi, 1956).

<sup>37</sup> Krishnamachari, "Inaugural Address", p. 3.

in addition to a vast number of smaller projects.<sup>38</sup> It is significant that two of the three large multipurpose projects in addition to one of the four largest state projects were in eastern India, which, with its high rainfall had seen little irrigation development during the colonial period. Also notable is the large number of projects in Bombay and the Deccan which had also seen previously little irrigation development as the storage-based irrigation its geography entailed was deemed too expensive in the colonial period.<sup>39</sup>

### **Irrigation in crisis**

By the late 1950s, the large irrigation projects ran into several difficulties. To begin with, there were problems of cost and schedule overruns, sometimes on a monumental scale. By March 1956, potential for only 6.3 million acres of irrigation was created under the major and medium schemes compared to the target of nearly 9 million acres.<sup>40</sup> This shortfall was at least in part a result of postwar development enthusiasts having set too high a target for themselves in seeking to increase the acreage irrigated by canal systems by nearly 50% in five years. A similar relative increase had taken over 20 years in early twentieth-century British India.<sup>41</sup> Much of the latter increase had taken place in Punjab, UP and Sind which had somewhat reasonable administrative systems for irrigation development. But postcolonial plans included states such as Madhya Pradesh (the Chambal Project) which lacked experience in “this type of work”.<sup>42</sup> The last two decades of British rule had seen little new development of surface irrigation anywhere, resulting in Chief Engineers reaching their positions with experience in operation alone, rather than in construction. In any case, the new projects involved reservoir and dam construction which presented challenges of an entirely different kind; even the best irrigation departments in the country had little experience with the same.<sup>43</sup>

But delay in creating potential was not the only problem. Irrigation engineers usually deemed irrigation potential to have been created when the structures to store or divert water had been built and distributaries to outlets capable of irrigating a couple of hundred

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<sup>38</sup> Compiled using Planning Commission, *Development schemes*.

<sup>39</sup> Compiled using Planning Commission, *Development schemes*.

<sup>40</sup> Planning Commission, *The Second Five Year Plan* (New Delhi, 1956), p. 121.

<sup>41</sup> For the change in the quadrennial average in area irrigated between the periods beginning in 1912 and 1932 as mentioned in Whitcombe, “Irrigation”, p. 701 has been used.

<sup>42</sup> Committee on Plan Projects, *Report on the Chambal Project* (New Delhi 1958), p. 17.

<sup>43</sup> Krishnamachari, “Inaugural Address, p. 4.

acres each had been constructed. The creation of this potential however, did not necessarily mean the facilities would be put to use; utilization required the building of field channels right upto the cultivators' fields in addition to preparing and levelling of land to receive irrigation.<sup>44</sup> Initial figures for the utilization of the potential created during the first plan began to emerge around 1957 and only about 4 million acres of the 6.3 million acres of irrigation potential created was reported to have been utilized;<sup>45</sup> final figures published in the Third Plan Document placed the utilization of the new potential created at just 48% in 1955-56.<sup>46</sup> From the late 1950s to the present day, this crisis occupies a large space in the discourse on large-scale irrigation systems in India.

Again, this perceived crisis was a function of expecting too much too fast. In the late 1940s, the economist DR Gadgil wrote that at least 30 years were required for an irrigation project to produce its full benefit.<sup>47</sup> William Stampe too had been apprehensive about large irrigation projects as they would take decades to develop. In contrast, the Committee on Plan Projects of the National Development Council deemed even ten years as a "leisurely pace" only justified "in the olden days" and allocated merely four to five years for a project to deliver its full benefit, including the application of improved methods of cultivation and more expensive inputs.<sup>48</sup>

While many projects lagged in the construction and utilization aspects, the spectacular failures of a few projects contributed significantly to the poor all India picture in the 1950s and 1960s; a case in point is the Kakrapar project in Gujarat, whose Superintending Engineer himself described it in 1957 as a "very expensive one which had miserably failed to serve its original objective and utility."<sup>49</sup> It was the only project whose construction was carried out by the Central Water and Power Commission (CWPC) rather than the provincial government. The project was sanctioned by the Bombay government in 1949 at a cost of Rs. 62.6 million as a weir project, but at the instance of the Chairman

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<sup>44</sup> Planning Commission, *Evaluation of major irrigation projects: some case studies* (New Delhi, 1965), p. 10.

<sup>45</sup> B.G. Verghese, "Facilities for Irrigation not fully utilised", *Times of India* dated May 22 1957.

<sup>46</sup> Planning Commission, *The Third Five Year Plan* (New Delhi, 1961), p. 142.

<sup>47</sup> D.R. Gadgil, *Economic Effects of Irrigation* (Poona, 1948), p. 11.

<sup>48</sup> Plan Projects, *Chambal*, p. 33.

<sup>49</sup> Times of India News Service, "Lesser Utilisation of Irrigation Facilities: Superintending Engineer on Kakrapar Project", *Times of India* dated October 12, 1957.

of the CWPC, it was soon modified into a dam project costing Rs. 310 million.<sup>50</sup> In 1951, after some of the work had been carried out, it was decided to revert to a weir project. This resulted in a situation where different channels had been constructed to different design statements making for great difficulties in reconciling the hydraulic features of different structures. The design was changed yet again to the construction of both a dam (for perennial irrigation, flood control and power generation) and a weir (for seasonal irrigation). The weir was constructed by 1953, after which the Government of Bombay took over the project resulting in acute staff shortages as most engineers opted to return to the CWPC. The Right Bank Canal was completed by 1958 and the Left Bank Canal by 1960; 80% of the work on the construction of minors and sub minors had been completed by 1963.<sup>51</sup> Irrigation potential was first created in 1958-59, and as late as 1963-64 less than a quarter of the potential was utilized.<sup>52</sup>

There were various reasons for underutilization of the potential. To begin with, the very concept of irrigation potential was a contentious one; the prescribed cropping pattern might have called for lightly-irrigated crops but cultivators' preference for wet cropping would result in there not being enough water for irrigating tail end fields. But more usually, administrators focussed upon the problem of field channels. The responsibility for constructing field channels from the government outlets to the fields, sometimes two miles away, fell upon the cultivators who often did not have the resources to build and maintain field channels. The fact that government channels themselves were ill maintained prompted cultivators to ask how they were to maintain their channels with their meagre resources, if the government, with all the human and financial resources at its call, could not maintain its own. Land acquisition was also an issue; where a farmer was not willing to permit construction on his land, either the legislation for acquisition did not exist, or the administration hesitated to enforce the same. Even where field channels were excavated, improper design meant that water often did not reach the fields.<sup>53</sup>

While the irrigation bureaucracy often sought to reduce the problem of utilization to the problems of constructing field channels, others favoured a different explanation. A study

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<sup>50</sup> Planning Commission, *Major irrigation*, p. 51.

<sup>51</sup> Planning Commission, *Major irrigation projects*, p. 61.

<sup>52</sup> Planning Commission, *Major irrigation projects*, p. 62.

<sup>53</sup> Planning Commission, *Major irrigation projects*, p. 62-64.

by the Committee on Plan Projects for example emphasized that field channels were a necessary but not a sufficient condition for the utilization of irrigation,

So long as field channels are not constructed, the problem of field channels is put at the forefront and acts as a red herring to divert attention from the real problem, namely that of the cropping pattern. If a cultivator can be given a crop that yields to him a substantial income, he was willing to construct field channels himself.<sup>54</sup>

The poor agricultural planning of the irrigation projects can again be exemplified with the case of Kakrapar. An important reason for slow utilization was project planners' inadequate understanding of local agriculture and their consequent inability to match the irrigation to the needs of crops. The project was based on outdated statistics of the local cropping pattern which did not account for perennial crops such as sugarcane, vegetables, bananas and fruit trees; these were not to receive irrigation from the seasonal weir. Yet, these crops accounted for half of the utilized irrigation potential; if these were removed, utilization of the potential created was less than 13%.<sup>55</sup> The improper agricultural planning of the project was reflected in its very concept of irrigation potential which was declared annually rather than season-wise; the mere physical availability of water was taken as synonymous with potential. As the study noted, the timing of the supply was important; unless water was made available well in advance of the sowing season, it could not be utilized.<sup>56</sup>

Cultivators across the country showed great variation in their response to irrigation. At the macroscale, this was reflected most spectacularly in the fact that only 61% of the potential created had been utilized by 1971 in Bihar, which ranked 2<sup>nd</sup> in irrigation potential while Punjab, which ranked a distant 7<sup>th</sup> had utilized 97% of its potential.<sup>57</sup> In Coimbatore (Madras), waters of the Lower Bhavani Project were "used as rapidly as they could reach the channels" and peasants paid not only for the water, but also heavy fines to defy water rationing by irrigating paddy. Raichur in the nearby province of Mysore which received water from the Tungabhadra Project, however did not take to irrigated

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<sup>54</sup> Planning Commission, *Major irrigation projects*, p. 43.

<sup>55</sup> Planning Commission, *Major irrigation projects*, p. 63.

<sup>56</sup> Planning Commission, *Major irrigation projects*, p. 63.

<sup>57</sup> Kusum Nair, *In Defense of the Irrational Peasant: Indian Agriculture after the Green Revolution* (Chicago, 1979), p. 141.

agriculture as enthusiastically. Even farmers through whose property the channels passed through sometimes did not irrigate, despite heavy propaganda and water being offered free of charge. In Orissa, the Hirakud project was to enable two crops of paddy a year, but local belief held that the soil could not take two paddy crops in the same year. In one village, the agricultural extension officer had to go on hunger strike to convince farmers to sow a second crop. That the slow response to irrigation was not merely due to such superstition or a lack of experience was demonstrated by some villages of Andhra's Kurnool district which also benefited from the Tungabhadra project. Peasants in the area had long been irrigating their fields from the Kurnool-Cuddapa Canal which had been built in 1871. However, they expressed satisfaction with their existing irrigated acreage and exhibited no desire to irrigate more land. Some favoured a technocratic explanation based on inadequate agricultural planning leading to poor incentive to take up irrigation. To others such as the journalist Kusum Nair who wrote an influential study on "the human element in Indian development," the variation of responses to irrigation across the country negated the implicit assumption in the planning process that given equal opportunity, incentive and resources, all communities would respond similarly in their productive efforts. According to her, the differences were not the result of administrative inefficiency, but had deeper roots in traditional beliefs about work, surplus production and diet. As she saw it, it was easier to build a million tonne steel plant than to change a man's outlook on the use of irrigation, "one of the oldest and most elementary techniques" in agriculture.<sup>58</sup>

This crisis of high cost, slow construction and slower utilization was the context for an important speech by Nehru. Addressing the Central Board of Irrigation and Power in 1958, he bemoaned "the disease of gigantism" that afflicted irrigation in India. Emphasizing the value of small projects, he touched upon the problem of utilization,

The cost of a small project has to be judged after taking into account all the social upsets connected with the enormous concentration of national energy, all the national upsets, upsets of people moving out and their rehabilitation and many other things, associated with a big project. Also it takes a long time to build a big project. The small project, however, does not bring about these upsets nor does it

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<sup>58</sup> Kusum Nair, *Blossoms in the Dust: The Human Element in Indian Development* (London, 1961).

involve such a large endeavour.... I merely wish if I can to replace the balance in our thinking which has shifted too much towards gigantic schemes. State Governments are constantly pressing our Government, our Planning Commission for various schemes- all huge schemes- and they have a right to do so. But this is all the relic to gigantism to which we have fallen a prey. We have to realize that we can meet our problems much more rapidly and efficiently by taking up a large number of small schemes, especially when the time involved in a small scheme is much less and the results obtained are rapid. Further, in those small schemes you can get a good deal of what is called public co-operation and therefore, there is much social value in associating people with such small schemes... On one side, we carry out irrigation and put more and more water for fresh areas, while on the other side land goes out of cultivation due to water logging... it is bad engineering if you cannot hold what you have already got in the process of acquiring more... the engineer may say "I have done my job by creating these resources; it is upto somebody else to utilize them". This is partly true, but not wholly true. .. No plan should proceed as it did in the old days without the utilization part being worked out. I have been hearing of the difficulties as to the utilization part. For instance, you dig a canal but the channels to take it to the village areas where they are needed are not ready. It is happening all over the place in India. It surprises me that there is such lack of coordination. It is not the fault of the engineers; it may be the fault of other departments, of State Governments. But I think engineers should not keep aloof from them. It should be a part of their work to see that the resources are utilized.<sup>59</sup>

While Nehru emphasized the value of small projects in his speech, minor-irrigation projects were not immune to the utilization problem. In Gujarat for example, utilization of minor irrigation stood at a poor 36%.<sup>60</sup> State tubewells in particular were also not immune to the problem of rising costs, falling revenue and poor utilization.<sup>61</sup> By the early

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<sup>59</sup> Jawaharlal Nehru, "Inaugural Address", in Central Board of Irrigation and Power, *Annual Report (Technical) of the CBIP, 1958* (New Delhi, 1960).

<sup>60</sup> Committee on Plan Projects, *Report on minor irrigation works (Gujarat State)* (New Delhi, 1963), p.7.

<sup>61</sup> See Committee on Plan Projects, *Report on State Tube-wells (Punjab)* (New Delhi, 1959) and Committee on Plan Projects, *Report on State Tube-wells (Uttar Pradesh)* (New Delhi, 1961).

1960s, the poor performance of public tubewells had led Punjab to stop building new tubewells and instead incentivize private tubewells.<sup>62</sup>

The editors of the *Indian Journal of Power and River Valley Development* took exception to Nehru's charge and argued that it was wrong to single out irrigation engineers when "all sections of the national elite... were equally affected by the virus". This was why state governments were engaged in a "feverish race" to get larger and larger projects sanctioned. This "craze for bigness" was not confined to India but afflicted the USA and the USSR as well; the only difference being they could afford to pay for it and India couldn't.<sup>63</sup>

### Second and Third Plans

While the first five year plan had been a mere statement of ongoing development projects, the second plan (1956-61) carried a greater imprint of the central government. Authored by the renowned statistician P. C. Mahalanobis who developed a model of the Indian economy that borrowed much from the GOSPLAN, it was a push for rapid industrialization and reflected the aspirations of the technocratic central elite. The allocation for industry, which only 7.6% of the total outlay in the First Plan, increased to 18.5% of the much larger Second Plan.<sup>64</sup> But while the Planning Commission pushed for the left-Nehruvian ideal of rapid industrialization and was ambivalent towards agriculture, it was merely an advisory body; while it had some say in central government fund allocation, it could not outright prevent the states from taking up irrigation projects. Irrigation continued to claim a significant share of public investment in India and was allocated about the same amount of money as had been spent during the first five year plan though it formed a smaller share of a larger outlay.<sup>65</sup>

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<sup>62</sup> Committee on Plan Projects, *All - India review of minor irrigation works based on state-wise field studies* (New Delhi, 1966), p.32.

<sup>63</sup> Anon., "Disease of Giganticism", *Indian Journal of Power and River Valley Development* (1958) 8: 168.

<sup>64</sup> Planning Commission, *Second FYP*, p. 7.

<sup>65</sup> About Rs. 3.40 billion had been spent on large irrigation projects during the First Plan and Rs. 2.09 billion were expected to be spent on First Plan projects during the Second Plan to irrigate an additional 9 million acres by the end of the Second Plan. The new large schemes of the Second Plan were expected to irrigate about 15 million acres on completion, at a total cost of Rs. 3.80 billion. Of this, about Rs. 1.72 billion was expected to be spent to irrigate 3 million acres by the end of the Second Plan. No projects costing



Notwithstanding fund allocations being kept up, the text of the report reflected the planners' frustration about irrigation. The continued inclusion of imperfectly investigated projects in the plan was bemoaned and the planners stressed the need for continuing investigation for which adequate machinery did not exist in all the states. There was even talk of carrying out studies as to what point irrigation would cease to become economical with the increasing application of better methods of dry farming and soil conservation.<sup>66</sup> There was disillusionment with minor-irrigation schemes as well; old works were falling into disuse, even as more land was brought under minor irrigation. The planners placed emphasis on legislation to ensure the maintenance of minor works.<sup>67</sup>

The events leading up to the formulation of the Third Plan (1961-66) reflected the tension of public investment in agriculture. A Planning Commission paper submitted to the National Development Council in January 1958 felt that the rise in agricultural production from 1949 to 1957 "did not reflect adequately the large outlays incurred during recent years on agricultural production programmes."<sup>68</sup> Irrigation shared a large part of the blame for this failure. According to the paper, not enough effort had been made to increase yields in areas already irrigated and there was a slow progress in utilization of the potential created. The minor-irrigation programme, which had been intended to draw popular participation had degenerated into a departmental construction programme and maintenance was unsatisfactory.<sup>69</sup> As a result of unfavourable weather, India's foodgrain production declined by 10% in 1957-58, rose in the subsequent year and marginally declined again in 1959-60;<sup>70</sup> proving that Indian agriculture continued to be a gamble in the rains despite large investments in irrigation, but perhaps also that much more needed to be done to make Indian agriculture drought-proof. In the midst of this crisis, the Ford

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more than Rs. 300 million were included in the plan (as compared to 7 in the First Plan), 10 were to cost between Rs. 100 million and Rs. 300 million (compared to 6 in the first plan), 42 between Rs. 10 million and Rs. 100 million (compared to 54 in the First Plan) with the remaining 136 costing less than Rs. 10 million (compared to about 200 in the First Plan). In addition to the 12 million acres expected to be brought under irrigation from large schemes, 9 million acres were expected to be brought under minor irrigation schemes. See Planning Commission, *Second FYP*, pp. 111-126.

<sup>66</sup> Planning Commission, *Second FYP*, p. 124.

<sup>67</sup> Planning Commission, *Second FYP*, p. 93.

<sup>68</sup> Anon., "The Right Approach," *Indian Journal of Power and River Valley Development* (1958) 8: 187.

<sup>69</sup> Anon., "The Right Approach," p.187.

<sup>70</sup> Ministry of Finance, *Economic Survey* (New Delhi, 1960) Accessed online at <http://indiabudget.nic.in/es1960-61/2%20Production.pdf> on 29<sup>th</sup> January 2015.

Foundation submitted its influential report *India's Food Crisis and Steps to Meet it*,<sup>71</sup> which was unambiguous on the importance of irrigation but argued that further investment in very large irrigation projects would not be productive. It called instead for a programme of agricultural intensification through the application of inputs such as fertilizers in areas already under irrigation.<sup>72</sup>

By the time of publication of the Third Plan, only 6.9 million acres of the 12 million acre target from large schemes in the Second Plan was expected to have been utilized.<sup>73</sup> The shortfall was blamed on inadequacy of cement, steel and technical personnel. In addition the report blamed the practice of commencing projects “under the pressure of local and regional demands” without adequate investigation.<sup>74</sup> Yet again, despite this observation, the planners were unable to impose a sense of control on irrigation investment except to feebly call for the prioritization of the completion of old projects “right upto the field channels” rather than to take up new projects.<sup>75</sup> But the Planning Commission was unable to impose this discipline and was forced to continue to allocate resources for new projects which would require little money during the Plan itself but much larger resources in later years.

Monies greater than ever before- Rs. 6 billion- were allocated to major and medium irrigation in the Third Plan of which only Rs. 1.64 billion was for new schemes.<sup>76</sup> To justify investment on new schemes which seemed contrary to its own advice, the Planning Commission offered strange explanations that the new schemes had been necessitated by particular circumstances. For example, a large scheme on the Beas was specifically to utilize India's share of the Indus waters (which had just been allocated in the Indus Water Treaty with Pakistan in 1960). Other schemes were deemed necessary to take up the irrigation component of projects that were primarily for power production or were necessitated by irrigation programmes undertaken in neighbouring states. Yet, no less

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<sup>71</sup> Agricultural Production Team (Ford Foundation) and Ministry of Food and Agriculture, *Report on India's food crisis & steps to meet it* (New Delhi, 1959).

<sup>72</sup> Francine Frankel, *India's Political Economy 1947-1977: The Gradual Revolution* (Princeton, 1978).

<sup>73</sup> Planning Commission, *The Third Five Year Plan* (New Delhi, 1961), p. 141.

<sup>74</sup> Planning Commission, *Third FYP*, p. 142.

<sup>75</sup> Planning Commission, *Third FYP*, p. 142.

<sup>76</sup> Planning Commission, *Third FYP*, p. 142.

than 95 new projects were sanctioned with no such special justification.<sup>77</sup> Despite its own observation that not enough was being done to utilize the irrigation potential being created fast enough, the Planning Commission appears to have had little choice but to accept the contention of irrigation engineers and state governments that such lags were inevitable; the Third Plan set lower targets for utilization than for potential creation and allowed for a considerable margin of time to achieve full utilization.<sup>78</sup>

The Third Plan placed much more emphasis than before on minor-irrigation projects; this was understandable considering the general atmosphere of disillusionment with large projects that had set in by the late 1950s even as frequent drought underlined the need for irrigation. The Plan emphasized that the total allocation for minor irrigation was as high as Rs. 2.5 billion (nearly half of the allocation for major projects) in addition to loan finance to support the efforts of individual cultivators.<sup>79</sup> Alluding to private tubewells, a particular emphasis was placed on the role of rural electrification in irrigation; the introductory paragraph of the plan for agriculture noted that “rural electrification is already beginning to make a significant impact on rural life through extension of irrigation and speeding up of technological change”.<sup>80</sup> At Rs. 1.05 billion, the allocation for rural electrification for the five years between 1961 and 1966 was higher than what had been spent on the same in the preceding ten years.<sup>81</sup>

### **From the dictates of the market to the planned economy of the welfare state.**

Questions of public finance were at the core of debates about irrigation projects. While allowing for considerable flexibility in practice, the Planning Commission had been unwilling to formally give up the colonial policy of using financial productivity as the primary criteria for sanctioning irrigation projects. Its response to the high cost of storage-

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<sup>77</sup> Planning Commission, *Third FYP*, p. 142-143.

<sup>78</sup> Planning Commission, *Third FYP*, p. 142-143. The plan set a larger-than-ever-before target of creating an irrigation potential of 13.8 million acres from old large schemes and 2.4 million acres from new schemes during the Third Plan. A more realistic target for utilization was set at 12.8 million acres which would include 3.2 of potential estimated to be unutilized during the Second Plan; this assumed a full utilization of five years from water availability at the outlet in the case of major schemes, and two to three years in the case of medium projects.

<sup>79</sup> Planning Commission, *Third FYP*, p. 56.

<sup>80</sup> Planning Commission, *Third FYP*, p. 56.

<sup>81</sup> Planning Commission, *Third FYP*, p. 56.

based irrigation was to call for the states to revamp the revenue structures of irrigation projects. Suggested measures included increasing water rates and recouping some of the capital cost itself by imposing a “betterment levy” on landowners;<sup>82</sup> predictably hardly any state took up these unpopular suggestions. On the contrary, the proponents of massive capital investment in irrigation projects called for rejecting the financial productivity test as the primary metric for the sanctioning of irrigation projects, and their arguments went to the heart of what it meant to be a welfare state.

Irrigation engineers had long argued that there were considerable social benefits of their projects which ought to be taken into account while sanctioning projects, but the head of the Planning Commission V. T. Krishnamachari opined in 1953 that once such benefits were granted legitimacy, there would be “no knowing where to stop”; the financial productivity test had “stood the test of time”.<sup>83</sup> But in 1959, a study by the newly set up National Council of Applied Economic Research (NCAER) argued that while the financial productivity test was appropriate for a *laissez faire* colonial economy where investment decisions were made according to the “dictates of the market” it failed “the planned economy of the welfare state”.<sup>84</sup> A welfare state required investment in overheads that were not amenable to marginalist analysis (exemplified by the financial productivity test); what was required was *total* analysis of social costs and benefits. The study proposed to replace the financial productivity test with cost benefit analysis which took into account the total social costs (both the cost of the project to the government and the investment required of cultivators to prepare land for irrigation among other things) and the total benefit (increased production etc.); projects were to be sanctioned if the ratio of benefits to costs was more than a chosen number. This method had apparently been adopted by the United States in 1950. The report criticized the government and the Planning Commission for sticking to a “narrow viewpoint” when it came to irrigation, though India had declared herself a welfare state and had an expanding public sector

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<sup>82</sup> Planning Commission, *First FYP*, p. 83.

<sup>83</sup> Krishnamachari, “Inaugural Address”, p. 5.

<sup>84</sup> NCAER, *Criteria for fixation of water rates and selection of irrigation projects* (Bombay, 1959), p. 122. The NCAER was a think tank funded by the Ford Foundation, the Tatas and the Indian government.

where decisions on expenditure and taxation in other domains were made with a view to establishing a socialist society.<sup>85</sup>

While the NCAER study was about investment decisions, it was explicit in directing its intervention at the utilization crisis of the late 1950s. At the suggestion of the Central Water and Power Commission, it took up the Sharda Canal in UP to exemplify the merits of cost benefit analysis. The scheme, among the last canal projects constructed in colonial India was far from typical; the considerable controversy over its sanctioning, its indifferent impact on agriculture and the loss it represented to the exchequer have been especially highlighted by historians.<sup>86</sup> But by arguing that the application of cost benefit analysis, together with a full economic survey (which would have noted that the highly developed well irrigation practiced in the tract obviated the need for canal irrigation) would have resulted in considerably more caution, the NCAER study sought to prove that the new method would reject projects that might run into difficulties later.<sup>87</sup> By highlighting such an exceptional case of rejection, this made an investment criteria favoured by the irrigation engineers (and the provinces) who wanted to build large projects more palatable to the Planning Commission and the central government which didn't.

Another advantage of cost benefit analysis touted by the study was the order it would help impose order on the *ad hoc*, chaotic and subjective decisionmaking process which was extant in the 1950s due the dilution (though not outright rejection) of the financial productivity test. In 1964, the central government ministry of irrigation appointed a committee to go into this vexed question of centre-state relationship. Consisting mostly of provincial ministers, the committee predictably opined that the development of irrigation in the country was "seriously jeopardized" by the restrictive financial productivity test and recommended that it be abandoned in favour of the cost-benefit analysis detailed by the NCAER;<sup>88</sup> this recommendation was accepted by the government. While a crisis of public finances in the late 1960s brought fresh investment

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<sup>85</sup> NCAER, *Criteria*, p. 123.

<sup>86</sup> See for example Whitcombe, "Irrigation," pp. 713-14.

<sup>87</sup> NCAER, pp. 46-79.

<sup>88</sup> Improving Financial Returns, *Report*, p. 47.

in large projects to a virtual halt, the adoption of the cost benefit analysis method played a role in the renewed momentum with which new projects were sanctioned in the 1970s.

Equally vexed was the question of how beneficiaries and the public exchequer at large should pay for irrigation. Water rates had been fixed using widely varying formulae in the provinces of colonial India but they were large determined by the capital and working cost of projects. As a whole, irrigation works in India were making a small profit at the beginning of the planning period. By the end of the First Plan, the sector was making a loss due to the crisis of utilization, the rising costs of new projects and the provinces' inability to raise rates on existing schemes; these losses grew as the decades wore on. The NCAER study argued that in a welfare state, the net benefit of irrigation to the cultivator, rather than the cost of the project should be the key metric to determine water rates. According to the NCAER, the precise proportion of the net benefit of irrigation appropriated by the state was necessarily a political choice which was to be determined by what was "convenient and expedient" for the state at any given moment; the study recommended that the percentage be between 20 and 50 percent.<sup>89</sup> This would have very probably resulted in the raising of water charges to a level more commensurate with the rising cost of projects.<sup>90</sup>

In 1964, the committee of provincial ministers agreed with the NCAER that net benefit should be the criteria for fixing water rates.<sup>91</sup> But losses on irrigation projects continued as the states seldom raised water rates in practice. These losses continued to be central to much of the discourse on irrigation and the question of who should pay for development which favoured the few refused to go away. In 1985, when B.B. Vohra, India's first high profile crusader against big dams castigated irrigation projects for these losses at a seminar on irrigation, Karnataka Chief Minister H. D. Deve Gowda (who later became Prime Minister) responded by charging the central government of disavowing irrigation; such a narrow view was not taken when funds were poured into public sector industries.

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<sup>89</sup> NCAER, *Criteria*, p. 152.

<sup>90</sup> NCAER, *Criteria*, p. 153.

<sup>91</sup> Improving Financial Returns, *Report* (New Delhi, 1964), p. 44.

He argued that cost could not be a criterion for development; it was the duty of the state to make agriculture profitable.<sup>92</sup>

## Conclusion

Nehruvian India devoted substantial resources to irrigation, which was seen as the basis of a technological transformation in agriculture. This investment however took place due to the commitments made in the late colonial period and due to provincial pressures, rather than being imposed by the elites in the central government. Influential technocratic bodies such as Planning Commission were circumspect and even critical of investment in irrigation, particularly in the case of big schemes but were unable to impose their writ on state governments; this resulted in the almost wanton proliferation of large projects. Those favouring such projects couched their arguments in terms of the responsibilities of the welfare state which the central government was forced to accept. This provides an insight into the centre-state in early postcolonial India and raises serious questions of whether the development praxis of the era can be characterized by the ideas of central elites alone.

The big dam in India had its genesis not in a fetishization of the TVA but in the quest for irrigation in India. Dams had been long proposed in colonial India but few were built as they were seen to be expensive and technically challenging. They rose to prominence in the immediate postwar era with the perceived exhaustion of the possibilities of conventional river diversion schemes, the rise of a developmental state more willing to spend money to mitigate continuing food crises, and the rising importance of power production which helped make irrigation dams viable. Investment in irrigation in Nehruvian India went beyond gargantuan prestige projects to embrace a wide variety of small-scale irrigation technologies. The centrality of irrigation in India's water development plans and the significant public investment in small-scale irrigation schemes negates the assumption that the ideological example of the TVA (which did not provide for irrigation) was the all-important motivation for dam building in India; in any case few of India's dams bore comparison to the TVA. In the next chapter, I will show detail just how significant India's commitment to tubewell irrigation in the Nehruvian era was.

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<sup>92</sup> Times of India New Service, "Centre disfavours irrigation projects", *Times of India* dated December 17<sup>th</sup> 1985.

By the late 1950s, India's irrigation projects ran into several difficulties such as cost escalation and overrun of schedules. An additional problem was the slow utilization of the water impounded at great cost for irrigation; this crisis of utilization has dominated the discourse on public irrigation facilities in India. To the irrigation engineer, this crisis was one of building the last-mile infrastructure to deliver water to the fields which was usually the responsibility of the cultivator. For others, this crisis was due to a failure in planning an appropriate cropping pattern which made irrigation profitable to the peasant. But for some critics of planned rural development in India, the crisis had deeper meaning; the wide spectrum of successful and failed irrigation projects disproved an assumption central to planning and rural development in India. This assumption went that given equal incentives and resources, all communities would respond similarly in engaging with opportunities for economic development; cultural difference still mattered. In subsequent chapters, I will explore how a shift in the intellectual landscape of development studies in the mid-1960s formalized and solidified this assumption.



## **Chapter 4: Tubewells in Postwar India**

In this chapter, I shall tell the story of tubewells in India between the mid-1940s and the mid-1960s. I shall argue that postwar India invested substantially in tubewell irrigation continuing the colonial-era trend of India being at the forefront of tubewell irrigation. I will further show how postwar Indian investment in tubewell irrigation began with the execution of Stampe's grand plans after he left India.

I shall begin with the story of a small tubewell scheme in UP championed by William Stampe in the last few months of his time in India and detail the negotiations over the finances of that project between a conservative central government and an extravagant provincial government as an example of the centre-state conflict in irrigation development I had outlined in the last chapter. I shall go on to detail Stampe's grand plans for tubewells in postwar India and their execution by early independent India. In studying the race between British and American firms to win the contracts for that programme, I shall argue that the Cold War context was only one reason for the West's support for Indian agricultural modernization; the profits that would accrue to western firms in the process was an equally important factor.

Finally, I shall outline tubewell development in India through the 1950s. I shall argue that while irrigation planners were circumspect about the (still very) new mode of irrigation and the lack of knowledge about India's groundwater resources; they nevertheless made large investments in public tubewell programmes. In this, they were supported by significant American aid, both for tubewell construction and for the All India Groundwater Exploration Project which helped increase confidence about India's groundwater resources; both programmes were the largest of their kind in the world. Through the decade, the public sector rather than individual cultivators was at the forefront of tubewell development.

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Histories of postwar India have characterized gigantic dam projects as central to water resources development in independent India. This notion is not confined to specialized studies of dams but extends to more general accounts of the period; for example Sunil Khilnani has titled his chapter on economic development "Temples of the Future" after

the appellation Nehru gave to big dams and has claimed that in the 1950s, India “fell in love with the idea of concrete” in the form of dams.<sup>1</sup>

The battle against communism has been seen as primary motivation for the west’s support for agricultural modernization in India. Indeed both book length histories of the Green Revolution which touch substantially on the Indian case have the phrase “Cold War” in the title and argue that American aid for Indian agriculture was motivated by a fear of the spread of communism; particularly by the imminent victory of the communists in the Chinese civil war in the late 1940s.<sup>2</sup>

### **The Gorakhpur Leopard Tubewell Scheme**

In 1945, the UP Irrigation Branch put forth a proposal to construct tubewells and electrify the district of Gorakhpur. Known variously as the Gorakhpur ‘Leopard’ Tubewell Scheme and the Trans-Gogra Tubewell Irrigation Scheme, the proposal envisaged the construction of a hundred tubewells of the Roscoe Moss design, eighteen of which were to be constructed by the Central Groundwater Organisation (CGWO) to demonstrate mechanical drilling. Cheap power was expected to be available within five years from the Rihand dam; in the meanwhile, Stampe suggested that power be supplied from a nursery power plant. The nursery power plant was to be owned and operated by the Government of India and power provided to the UP government at a low rate to encourage tubewell irrigation; the loss on power production was to be borne by the central government. UP was to have the option of purchasing the plants at the end of five years and it was also to be indemnified against all losses on the scheme in case the Government of India failed to supply power from the power stations in time.<sup>3</sup> The cost to the Government of India of supplying power at a loss was estimated by Sir William at half a million rupees; on that basis, approval for the scheme was granted in principle by the Department of Agriculture

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<sup>1</sup> Sunil Khilnani, *The Idea of India* (New Delhi, 1997), pp.61-62.

<sup>2</sup> See John Perkins, *Geopolitics and the Green Revolution: Wheat, Genes and the Cold War* (New York, 1997) and Nick Cullather, *The Hungry World: America’s Cold War Battle against Poverty in Asia* (Cambridge, Ma, 2010).

<sup>3</sup> “Minutes of a technical discussion on 1/6/46 in Naini Tal dated 1.6.46”, in NAI File: Trans Gogra Tubewell Scheme. Two 2500 kilowatt oil fired Yarrow/B.T.H turbine sets manufactured for European and Russian rehabilitation were to be converted to dual firing or for use with coal.

and the generating sets were ordered. Soon after this, in August 1946, Stampe fell ill and left for the UK.<sup>4</sup>

However, soon after the Department of Agriculture committed to the scheme, it was discovered that the estimate was erroneous and that the real cost of the power supply subsidy would be closer to the prohibitive figure of two million rupees.<sup>5</sup> One may well speculate the extent to which the initial erroneous calculation which led all parties to commit to the scheme was “honest”; Stampe and the UP Irrigation Branch had a history of bureaucratic errors which enabled the sanctioning of projects which would otherwise not have been approved.<sup>6</sup> To preserve the “honour and good name of the Central Government” and put to use the ordered power plants which were already on the high seas, various alternative financing proposals made the round in the latter half of 1946 and early 1947 between the Finance Department and the Department of Agriculture, with the latter firmly on the side of the UP Government in trying to extract the highest possible subsidy.<sup>7</sup>

UP was to receive several subsidies for the scheme; a free power plant, subsidized power and the construction of some tubewells for free by the CGWO. In addition, UP was also to receive a subsidy on the construction of its own share of tubewells equal to the estimated annual increased food grain production under the Grow More Food scheme. The Finance Department discovered this fairly late in the course of the negotiations in January 1947 and found it unacceptable that UP was to receive multiple subsidies on

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<sup>4</sup> K.D. Sanwal, Note dated 16 August 1946, in NAI File: Trans-Gogra Tubewell Irrigation scheme.

<sup>5</sup> K.D. Sanwal, Note dated 16 August 1946.

<sup>6</sup> For example, the first three power stations of Ganges grid was presented as three separate projects each costing less than the minimum expense requiring the approval of the Secretary of State and retroactively converted into one large project; this was even as the vision of an interconnected grid had existed from the very beginning. The steam station at Chandausi was built as it was realized that the cost of transmitting hydroelectric power to that location was high, but that realization came only after the transmission lines were already built enabling the steam station to act as a standby in case of canal closures. See Kapil Subramanian, “Canals, Sugarcane and Tube-wells: System Building in an Agrarian Economy”, (unpublished masters dissertation, Imperial College, London, 2011).

<sup>7</sup> PM Kharegat, Secretary, Department of Agriculture to Narhari Rao, Secretary, Department of Finance, 27 January 1947, in NAI File: Trans-Gogra Tubewell Irrigation scheme.

different parts of the same scheme. It also raised concerns over the generally high cost of the scheme and suggested that UP not go ahead with the scheme at all even if it were financed completely from the province's own funds. Finally, it raised questions over the projected increased food production from tubewells, which would have a bearing on the Grow More Food grant. While the project proposal mentioned a yield increase of five maunds per acre of wheat, UP's representative at a Food Conference had casually mentioned that such an increase would only take place in conjunction with fertilizers; the increased yield by tubewells alone would be about half the amount. After much protracted negotiation, the Finance Department agreed to a total subsidy about equal to what UP would have been eligible for under the Grow More Food scheme, and the UP Government proceeded on that basis.<sup>8</sup> The episode demonstrates that controversies over subsidies to technology in agriculture have a history that goes beyond the populist politics of the post Green-Revolution era. It also illustrates that it was difficult to apportion yield increases to particular technological changes.

The electrification of Gorakhpur district under the project was begun in 1948,<sup>9</sup> and proceeded slowly, partly because the Rihand Dam which was to supply power for the scheme within five years of 1947 only started producing power in 1962.<sup>10</sup> While the initial proposal for the dam project in the early 1940s had centred on the energization of 4000 tubewells, industrial interests (including a Birla-owned aluminium smelter) controversially managed to get a large chunk of the power allocated to themselves in the late 1950s.<sup>11</sup> Nursery schemes would last well into the 1960s;<sup>12</sup> the realization of Stampe's Himalayan Dream was to take much longer than he had expected.

### **Decolonization**

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<sup>8</sup> Principal Secretary (Planning, Department of Finance), Note dated 1st February 1947, in NAI File: Trans Gogra Tubewell Scheme.

<sup>9</sup> United Provinces Public Works Department, *Irrigation Administration Report of the United Provinces 1947-48* (Allahabad, 1948).

<sup>10</sup> SK Saini, "The Rihand Dam: A Historical Study", *Indian Journal of Research* (2011), 5:39-44.

<sup>11</sup> Anon., "Distribution of Rihand Hydel Project Power", *Times Of India*, 29 March 1959.

<sup>12</sup> They were mentioned, for example in Energy Survey of India Committee, *Report of the Energy Survey of India Committee* (New Delhi, 1965).

Stampe left India on leave due to ill health in 1946, and, having suffered an accident during a visit to America in early 1947, gave up his position as Irrigation Adviser. In 1946 a delivered talk to the East India Association in London outlining the Himalayan Dream, saying it could be a perfect example of a new cooperative partnership between East and West,

I am convinced that the ideal way to encourage lasting comradeship between East and West is for both parties to take part — the one as owners and custodians of their own destinies, the other as possessing longer mechanical experience as well as greater factory resources — in fostering India's agricultural economy.<sup>13</sup>

In this section, I shall explore the early beginnings of that new partnership.

In 1946, Stampe had proposed a scheme to sink a few thousand tubewells in UP, Bihar and Punjab. He had suggested that a British or American firm be contracted to do the job and had even discussed it tentatively with an American firm during his visit to that country. According to Stampe, the proposal was “summarily rejected” with the involvement of foreign firms being the only reason.<sup>14</sup> However, the Government of India had not rejected large-scale tubewell construction altogether; for example a plan to build 6000 tubewells in 6 years was discussed in May 1948.<sup>15</sup> The government had also invited Clarence Johnston of the Californian firm Johnston Pumps, and Leon Hostetter, a professor of agronomy at the University of California for discussions.<sup>16</sup> But the newly-independent government moved slowly and this came in for much criticism; for example a retired Secretary of Agriculture from Stampe’s time, Sir Pheroze Khareghat wrote in the *Times of India* that the country could not meet Nehru’s target of food self-sufficiency by 1951 as “what hope is there of speedy action when the Government take seven months merely to print a report on the feasibility of sinking tubewells.” Khareghat used tubewells

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<sup>13</sup> William Stampe, ““The Himalayan Dream” An address to the East India Association“, 17 December 1946, copy in British Library file IOR/L/E/8/5515.

<sup>14</sup> William Stampe, “Reasons prompting a groundwater ‘crusade‘”, 19 January, 1949, in British Library File: IOR/L/E/8/7431

<sup>15</sup> Anon., “6000 tube-wells in six years”, *Times of India*, 22 May 1948.

<sup>16</sup> J.N. McKelvie, (UK Trade Commissioner, New Delhi) to the Under Secretary (Export Promotion Department), 23 August 1948, in British Library File: IOR/L/E/8/7431

to illustrate the “practical difficulties” of agricultural development and wrote of CGWO’s difficulties and the obstacles to large-scale groundwater development,

It is now possible to use power operated boring rigs which can go down to a lower level and are much quicker to operate. Some of these rigs were obtained. But there were few men who knew how to work them properly. No adequate arrangements were made for the supply of the pipes required or for spare parts for dealing with the breakages or for the power pumps needed. There was considerable delay and little progress.

A suggestion was, therefore, made that an American firm which has been doing this type of work should be entrusted with the work of constructing, say, 1000 wells and train our men... There is in high quarters a reluctance to entrust work to foreign firms, nor are those in charge prepared to admit their lack of competence. And so nothing happens for months and years and the people must do without the food which would have been available had these tubewells been constructed.<sup>17</sup>

But the Government of India did proceed, and in consultation with the American experts, drew up a plan for sinking 4,565 tubewells in UP, Bihar and Punjab. While there may have been some hostility to collaboration with foreign firms, due to the lack of boring equipment, power plants and engines, strainer and casing pipes, and the inadequacy of trained personnel, Johnston Pumps was invited to put in a tentative tender. On the grounds that that the provinces could not carry out the work fast enough on their own, that the Americans would use better quality strainers, and that Indians could be trained on mechanical boring equipment better were the contract been given to an American firm, the central government preferred foreign collaboration.<sup>18</sup> Accordingly, in February 1949, the government signed a contract for the construction of 3000 tubewells with the Johnston Pump Company.<sup>19</sup> An application for a loan to cover the 55 million rupees of dollar

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<sup>17</sup> Pheroze Kharegat, “Can India wipe out food deficit by 1951?” *Times of India*, 15 August 1949.

<sup>18</sup> “Tubewell Construction“, in NAI file: Loan from the International Bank for Land Reclamation and Tubewell Construction.

<sup>19</sup> “India wants Irrigation Wells“, Reuters Trade Service, February, 1949, in British Library File: IOR/L/E/8/7431. The rest of the wells were to be constructed by the provinces.

expenditure of the total project cost of about 140 million rupees was submitted to the International Bank for Reconstruction and Development in the same year.<sup>20</sup>

Stampe visited India in 1949 and argued that the cost estimate submitted by Johnston Pumps was “fantastically high”; this cost was also criticized by legislators.<sup>21</sup> The International Bank also rejected the application for a loan on the grounds that “putting down a further 4000 tubewells in the Gangetic plain might lower the water table so much as to do more harm than good in the long run.”<sup>22</sup> The Bank demanded a geological survey before considering a loan, but the Indian government’s opinion was that a survey would take years and that they had enough data on which to base the project. There was some talk of turning out the groundwater survey carried out by J.B. Auden for Ganges Valley State Tube-Well Irrigation scheme in the 1930s which had indicated that supplies were ample enough to ensure no depletion, but the idea was shelved as the government felt that the amount of work required was disproportionately high in comparison to the small amount of the loan.<sup>23</sup> The central government decided to go ahead with a smaller scheme of technical and financial support to provincial tubewell programmes.

For the British, tubewell construction in the new dominion was of strategic importance as reflected in communication between the Commonwealth Relations Office and the Board of Trade,

The trouble with the new dominions is that they so often fail to put first things first and they tend to concentrate for prestige reasons on projects which are not likely to have any immediate effect in either raising the low living standards or even in staving off the recurring famines which threaten them. In the tubewell schemes however, we have an instance in which the Government of India are fully justified in raising finance wherever they can do so and in pushing with all energy with these schemes. It is not only in India’s interest that she grow more food and

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<sup>20</sup> “Tubewell Construction“, in NAI file: Loan from the International Bank for Land Reclamation and Tubewell Construction.

<sup>21</sup> DA Bryan (UK Trade Commissioner) to the Under Secretary (Board of Trade), 25 June 1949, in British Library File: IOR/L/E/8/7431.

<sup>22</sup> L Harrison, (UK Trade Commissioner) to Alec Symons, Commonwealth Relations Office, 9 December 1949, in British Library File: IOR/L/E/8/7431.

<sup>23</sup> L Harrison, (UK Trade Commissioner) to Alec Symons, Commonwealth Relations Office, 9 December 1949, in British Library File: IOR/L/E/8/7431.

reduce her dependence on foreign cereals, it is equally her interest that she should do so and reduce the calls which she has been and continues to make on her sterling balances especially that portion of the balances for which she looks to us in hard currencies.

Apart from economic angle, we can say that it is politically important that the Government of India should receive every help possible from us to carry through the scheme calculated to prevent unrest through the spread of famine and its attendant evils while at the same time enabling the Government of India to claim credit for the successful consummation of these projects on which indeed its political future at the next election may well depend. In the short term, it is by practical measures of this kind that Government of India can best fight communism.<sup>24</sup>

It would be tempting to conclude, that the West's support for the modernization of Indian agriculture was all about foreign exchange and the fight against communism.<sup>25</sup> This was indeed a concern and the Indian government was well aware that this could be exploited; for example in a telegram to the Indian ambassador in America requesting enquiries about reclamation tractors and tubewell equipment, Jairamdass Daulatram, the Minister of Agriculture said that while the US was not normally interested in enquiries from India as the demand for reclamation tractors was high, "the atmosphere for getting high priority for our requirements has improved" due to "the turn of events in China."<sup>26</sup> But for the British, a more immediate concern was the "shrewd suspicion" that the Indians had "practically committed themselves to a contract with an American firm" and the feeling that India was only trying to obtain from Britain the equipment she could not obtain from the United States.<sup>27</sup> For the Indians, preference for American goods had at least partly to

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<sup>24</sup> J. Thomson, Commonwealth Relations Office to G. Bowen, Board of Trade, 23 May 1949, in British Library File: IOR/L/E/8/7431.

<sup>25</sup> As has been argued by those such as John Perkins, *Geopolitics and the Green Revolution: Wheat, Genes and the Cold War* (New York, 1997).

<sup>26</sup> Jairamdass Daulatram to Indian Embassy (Washington, DC), 7 December 1948, in NAI file: Equipment for Land Reclamation.

<sup>27</sup> JN McKelvie (UK Trade Commissioner) to F. Doy (Commonwealth Relations and Export Department, Board of Trade), 1 February 1949, in British Library File: IOR/L/E/8/7431.



do with the fact that the Americans had more experience with groundwater development than the British did; when asked by the UK Trade Commissioner in New Delhi why the government was not purchasing more equipment from the British, Dr. Piplani, a Joint Secretary in the Ministry of Agriculture bluntly replied that there was no area in the UK which had tubewells.<sup>28</sup> However, with the failure to get a dollar loan, the Indian government was anxious to buy as much equipment as possible from the Sterling areas. As no British firm was large enough to take on the entire tubewell programme India envisaged, Brush Electric Works had formed a consortium of companies, registered in London as a nominal £100 company called Associated Tube-wells Ltd. to collectively undertake the job.<sup>29</sup>

While Associated Tube-wells progressed reasonably well in its negotiations with the Indian government on most matters, Indian engineers' insistence on the use of borehole pumps manufactured by Johnston Pumps was a sticking point; their manufacture in the UK by Associated Tube-wells would require substantial dollar royalties which UK exchange control would not permit.<sup>30</sup> Unlike the submersible pumps manufactured by British firms, the borehole pumps had their motor at the surface, permitting easy maintenance;<sup>31</sup> Roscoe Moss too had noted the preference for borehole pumps in India despite their high prices.<sup>32</sup> Stampe was consulted by the consortium about the extent of

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<sup>28</sup> JN McKelvie (UK Trade Commissioner) to F. Doy (Commonwealth Relations and Export Department, Board of Trade), 1 February 1949, in British Library File: IOR/L/E/8/7431.

<sup>29</sup> JN McKelvie (UK Trade Commissioner) to the Under Secretary (Commonwealth Relations and Export Department, Board of Trade), 12 May 1949 and UK Trade Commissioner to J Thomson (Commonwealth Relations Office), 12 April 1950, in British Library File: IOR/L/E/8/7431. The companies included Mertz and McLellan as consultants, and the Reliable Water Supply Company of Lucknow as a contractor (which, headquarter in Lahore before Partition had supplied the strainers for the original UP scheme).

<sup>30</sup> Telegram from Board of Trade to New Delhi, 14 April 1950 and UK Trade Commissioner to Commonwealth Relations Office, 15 April 1950, in British Library File: IOR/L/E/8/7431.

<sup>31</sup> Telegram from New Delhi to Board of Trade, 26 April 1950, in British Library File: IOR/L/E/8/7431.

<sup>32</sup> Roscoe Moss, "A brief review of ground-water potentialities and tube-well technique in Northern India", 19 Mar, 1946, in NAI file: Delegation of powers to the Chairman, CGWO.

preference for UK and American pumps in India.<sup>33</sup> He reported that submersible pumps of UK make were better than the American bore hole pumps, but the fact that some Harland pumps installed in UP in 1935 had performed poorly may have contributed to the poor reputation of British pumps in India. He wrote letters to engineers in UP, Punjab, Bihar and Bengal pointing out the superiority of British pumps and suggested that an Indian engineer be invited to come to the UK and see the pumps in operation. But his efforts on behalf of British manufacturers did not bear fruit and matters were not helped by the fact that a submersible pump sent by a British company for trials in UP had fallen into the bore after two months of operation.<sup>34</sup> It was felt that Stampe's word no longer carried weight in India.<sup>35</sup>

But the potential market in India was not to be lost due to Anglo-American competition or foreign exchange restrictions. With fears that negotiations with the Indians would fall through, Parson-Johnston (a collaboration between Johnston Pumps and the engineering contractor Ralph M. Parsons) and the Brush group agreed to collaborate rather than compete as their "resources were supplementary";<sup>36</sup> while the Americans were interested in groundwater engineering, drilling and pumps, Brush was interested in electrical machinery such as motors and generators for nursery power plants. It was decided that the world market for tubewells was to be divided into the Sterling and non-Sterling areas. For the purpose of initial sales solicitation, Associated Tube-wells was to take the lead and in the non-Sterling Areas, Parson-Johnston was to take the lead, though both were to collaborate in all markets. Johnston and Associated Tube-wells were to form a new company in England called Johnston-Atwell which would purchase pumps of Johnston's design manufactured by J&H McLaren in the UK to sell to both Associated Tube-wells and to Johnston Pumps. Associated Tube-wells was to change its name to Parson-Johnston-Brush International Ltd. and Parson-Johnston was to change to Parson-

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<sup>33</sup> "Minutes of a meeting held on Tuesday, May 2nd 1950 at 10.30 am in Room 1020, Shell Max House.", in British Library File: IOR/L/E/8/7431.

<sup>34</sup> Telegram from Commonwealth Relations Office to New Delhi, 12 May 1950, in British Library File: IOR/L/E/8/7431.

<sup>35</sup> Telegram from Board of Trade to New Delhi, 10 May 1950, in British Library File: IOR/L/E/8/7431.

<sup>36</sup> UK Trade Commissioner to Under Secretary (Board of Trade), dated June 8<sup>th</sup> 1950 in British Library File: IOR/L/E/8/7431. The communication contains the text of the agreement.

Johnston-Brush International. The royalty and other dollar payments to Johnston were to be facilitated by the supply of diesel engines and electric equipment such as motors and generators by Brush Electric Works to the Johnston Pump Company.<sup>37</sup>

These companies were to have significant impact on groundwater development in India in the coming decade. Under the name of Associated Tube-wells, the group got a contract to construct and equip 965 tubewells in UP, Bihar and Punjab in 1950,<sup>38</sup> which was “considered the largest single tube-well construction programme ever undertaken in the world”.<sup>39</sup> Johnston set up a pump manufacturing unit in Calcutta which continued to manufacture under the name Johnston Pumps India until it was renamed in the 1980s. In 1950, Parson-Johnston-Brush International was also awarded a contract by the Government of India to explore the groundwater resources in Orissa, Madras, Bihar, UP, West Bengal and Saurashtra, which laid the groundwork for the American aided All India Groundwater Exploration Project in the 1950s (which was executed by Parsons),<sup>40</sup> described in later decades as “forerunner of modern concept introduced in India in the search for ground water resources with a multi-disciplinary scientific approach.”<sup>41</sup> Parson-Johnston-Brush International’s exploration work also led to the identification of 2000 potential sites for sinking tubewells<sup>42</sup> which were developed with American aid in the 1950s; that project was again proudly described the largest tubewell construction programme anywhere in the world.<sup>43</sup>

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<sup>37</sup> UK Trade Commissioner to Under Secretary (Board of Trade) dated June 8<sup>th</sup> 1950 in British Library File: IOR/L/E/8/7431.

<sup>38</sup> Mansinghal Associates, *A Project Report on the Location of Information Sources Regarding Water Resources in India. For the United States of America Agency for International Development* (New Delhi, 1968), p. 50.

<sup>39</sup> Ministry of Agriculture *Tubewells in India* (New Delhi, 1955), p. 2.

<sup>40</sup> Ralph M. Parsons Company, *Final Report: All India Groundwater Exploration Project* (Los Angeles, Ca, 1959), p. 5-6. Copy available in the library of the Central Groundwater Board, Faridabad.

<sup>41</sup> T. Charlu and D.K. Dutt, *Groundwater Development in India* (New Delhi, 1982).

<sup>42</sup> Mansinghal Associates, *A Project Report on the Location of Information Sources Regarding Water Resources in India. For the United States of America Agency for International Development* (New Delhi, 1968), p. 51. Copy available in the library of the Central Groundwater Board, Faridabad.

<sup>43</sup> Ministry of Agriculture, *Annual Report* (Delhi, 1954), p. 47.

### **Tubewells in the 1950s**

The text of the first five year plan for irrigation had begun with an assessment of India's water resources. While tentative estimates could be made for the utilizable surface water resources of the country, in the case of groundwater the Commission could merely note that while substantial supplies were available, no inventory of India's groundwater resources had been conducted. While wells had been in use for irrigation since times immemorial, large-scale irrigation from the source was only thought possible with power-operated pumps and supplies for exploitation on a large-scale were only known to be available in UP, Bihar, Punjab, Rajasthan and Gujarat; a scheme for 400 large tubewells had been sanctioned in the latter in the pre-plan period. The circumspectness is understandable in light of the fact that tubewell irrigation had not established itself as a primary mode of irrigation on a large scale anywhere in the world in the early 1950s, and little was known about India's groundwater resources. UP still remained the only successful large example of tubewells in action and there, they were seen as useful in areas with good groundwater supplies not commanded by surface works as they were generally more expensive than canals. Nevertheless, the Commission's cautious optimism about motorized groundwater development was reflected in the emphasis it placed on the importance of electricity in agriculture. At 105%, the Plan's forecast for the increase in use of power for irrigation pumping over the next decade was the higher than for any other category of power users.<sup>44</sup>

State tubewell projects were included in the outlay for major irrigation schemes in the First Five Year Plan. Uttar Pradesh and Punjab and Bihar was where significant public tubewell development had taken place in the pre-plan period; the former two were also the leading canal irrigation provinces. Amongst the eighteen state irrigation schemes mentioned for UP, seven had to do with tubewells and their total cost accounted for over two thirds of the cost of all irrigation projects proposed by the province for the First Plan; this included an ambitious plan to build 15,000 state tubewells by 1967. In Punjab, three tubewell schemes accounted for over a third of the state government's expenditure on irrigation projects while in Bihar, tubewell projects accounted for over two fifth of the

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<sup>44</sup> Planning Commission, *The First Five Year Plan* (New Delhi, 1952), p. 92. The report also mentioned the large share of energy consumed by tubewells in UP and by the 12,500 agricultural pumps on the Madras grid as a good portent for future demand.

provincial outlay on irrigation development schemes.<sup>45</sup> Hence in the states where tubewell irrigation had proved feasible, public tubewell schemes formed an important part of development efforts.

What did these plans imply for the growth of India's public tubewell networks? About 2500 public tubewells were extant in India in 1951, 2300 of which were in UP. As was just detailed, a programme to construct an additional 965 tubewells in Punjab, Bihar, UP and PEPSU had resulted from William Stampe's efforts. In addition, the Plan provided for the construction of 700 tubewells under the Grow More Food Programme and 2480 tubewells under other provincial development plans.<sup>46</sup> The availability of American aid for tubewell construction provided a further fillip to India's tubewell programme. The Indo-US Technical Cooperation Agreement was signed between the two countries in January 1952 and the sixth of the hundred odd operational agreements under the treaty was one for the construction of 2000 tubewells in UP, Punjab, PEPSU and Bihar; this was later expanded to a further 650 tubewells. In all, the provincial plans, the Grow More Food scheme and the American aided project envisaged the tripling of the number of tubewells in India in just five years to irrigate a further 2.2 million acres. Building at the rate of about a 100 a month, India was engaged in the early 1950s in the world's largest programme of tubewell construction; as the Ministry of Agriculture proudly wrote, "no country in the world has ever attempted something of this magnitude in tubewell construction."<sup>47</sup>

The Planning Commission became more optimistic about tubewells in the Second Plan which began in 1956, noting that technological advances in tubewell engineering had increased the scope for their application. The All-India Groundwater Exploration Project, an American aided programme to explore India's groundwater resources through exploratory tubewells (which was again described as the largest such programme of its kind in the world<sup>48</sup>) was underway and more reliable information about subsoil water supplies was expected to become available soon. The plan envisaged the construction of

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<sup>45</sup> Compiled from Planning Commission, *Development schemes in the first five year plan* (New Delhi, 1952).

<sup>46</sup> Planning Commission, *First FYP*, p. 92.

<sup>47</sup> Agriculture, *Tubewell*, p. 4.

<sup>48</sup> Ministry of Agriculture, *Annual Report* (Delhi, 1954), p. 47.

3581 tubewells irrigating about a million acres under the minor-irrigation programme. While UP, Punjab, Bombay (Gujarat) and PEPSU dominated the programme, almost all provinces were allocated some tubewells, though of a smaller size in keeping with the availability of subsoil water. At the Planning Commission's instance, studies of the economics of tubewell irrigation had been initiated by some states as it was expected to become increasingly important in areas not commanded by canals.<sup>49</sup>

The use of electric power for irrigation increased fourfold in the 1950s, compared to an overall increase of 2.5 times in power consumption in India as a whole, reflecting the growth of motorized groundwater irrigation from state and private tubewells and pumps on open wells.<sup>50</sup> While reliable statistics of private tubewells are not available, the growth of tubewell irrigation in the 1950s was dominated by the state sector. As late as the early 1960s, an estimate stated that the number of private tubewells would only soon exceed state tubewells; the former also irrigated smaller areas.<sup>51</sup>

## Conclusion

Postwar India made substantial investment in public tubewell irrigation programmes. This investment began with the execution of Stampe's grand plans after his departure from India by the postcolonial government. Stampe believed that in his scheme for large-scale development of tubewell irrigation in India lay the potential for a new partnership between an industrial West and an agricultural East. The Anglo-American scramble for contracts to execute his plan demonstrates that the global fight against communism was but one reason for British support for agricultural modernization in India; the profits that would accrue to British firms in the process of that modernization was a more important motive. The decision of American and British firms to collaborate rather than compete in order to meet Indian engineers' preference for American pumps despite dollar shortages illustrates the importance they placed on getting a foothold in the Indian market. Their agreement illustrates how, even as global decolonization was in its infancy western corporations were splitting the new market for what could be called "development

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<sup>49</sup> Planning Commission, *The Second Five Year Plan* (New Delhi, 1956), p. 123.

<sup>50</sup> Planning Commission, *The Third Five Year Plan* (New Delhi, 1961), p. 142.

<sup>51</sup> Committee on Plan Projects, *All - India review of minor irrigation works based on state-wise field studies* (New Delhi, 1966), p. 47.

products” between themselves. These companies would have an important impact on the development of groundwater resources in India during the next decade.

The process of executing Stampe’s plans continued the interest of the central government in public tubewell irrigation that had begun during the War. Thus in the 1950s, despite the Planning Commission being circumspect about tubewell technology and India’s groundwater resources, the country embarked on the largest programme of tubewell construction in the world. In this venture, India was aided by American aid both in tubewell construction and groundwater exploration.

## Chapter 5: Transforming Traditional Agriculture

The historiography of the Green Revolution in India is centred on two themes; besides plant breeding, the other theme is the role of the United States in providing aid and building pressure on India to modernize its agriculture which played out in the context of the Cold War. On economic policy change, the well-known argument is that there was a shift in national priorities from industry towards agriculture in the mid-1960s.<sup>1</sup> But the existing literature neither tells us about the intellectual landscape of development studies that underpinned this shift nor provides a coherent account of the details of policy changes that would determine *how* these increased resources would be deployed to induce agricultural development.

In this chapter, I shall give an account of the particularities of policy changes that constituted India's New Agricultural Strategy of the mid-1960s. I shall argue that the central idea behind the New Agricultural Strategy (NAS) was that of the peasant as a rational economic being who would respond to state-incentives for higher production in his hunger for profit; thus his initiative could be placed at the heart of agricultural development efforts. Detailing the role played by Indian politicians, the World Bank and the United States government in shaping policy change; I shall argue that western advisors, particularly those connected with the World Bank's Bell Mission which visited India in 1964-65 played an important role in shaping agricultural policy.

The NAS's emphasis on agriculture as an engine of growth, as well as its emphasis on scientific research, on modern inputs such as chemical fertilizer and on incentives to the rational farmer to achieve that growth were intellectually underpinned by Nobel Prize winning economist Theodore Schultz's theory of the "poor but efficient" Third-World Peasant; a theory that itself owed much to economic research in India. At the time, both eulogists and critics would analyse the Green Revolution in Schultztian terms; indeed one Indian critic called his book "the Bible of the New Strategy".<sup>2</sup> I shall argue Indian agriculture was perhaps the first example of the application of the ideas of the Chicago School in the developing world. The seeming success of Schultz's ideas in engendering

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<sup>1</sup> See for example Nick Cullather, *The Hungry World: America's Cold War Battle Against Poverty in Asia* (Cambridge, Ma, 2010), pp. 210-222.

<sup>2</sup> See Yujiro Hayami and Vernon W. Ruttan, *Agricultural development: an international perspective* (Baltimore, Md, 1971) and Ranjit K. Sau, "Resource Allocation in Indian Agriculture", *Economic and Political Weekly* (1971) 6:A106.



a “Green Revolution” has been recognized by economists and policy experts (though not historians) in playing a crucial role in turning the attention of the World Bank to agricultural development; the idea of the “poor but efficient” peasant continues to be central to development thought.<sup>3</sup>

I shall begin with an overview of postwar economic development theory, aspects of which were central to India’s agricultural policy in the 1950s. I shall next detail the challenge to this theory posed by Theodore Schultz building on the field work of Canadian anthropologist-economist William David Hopper in India. Schultz argued that with the aid of research and modern inputs, agriculture could be an engine of growth and that peasants would respond to price incentives by adopting new technology to increase production.

I shall next look at new policies for agriculture introduced by the Shastri administration in India between 1964 and 1966. These were guided by ideas of Indians, by the advice of western economists with the Ford Foundation (including David Hopper) and the World Bank. I shall detail the setting up of a public sector trading company called the Food Corporation of India (FCI) which became one of the largest logistical operations in the world and argue that this was a significant and far reaching change, as it enabled the procurement of a significant amount of food from the countryside for cheap sale in the cities thus obviating the need for wheat imports as a source of central government stocks.

This was followed by the adoption of new technologies. I shall demonstrate how, in the case of chemical fertilizers, there was no consensus on their superiority to organic manures whose potential for cheap growth had barely begun to be utilized in India. Chemical fertilizers won policy over through intense lobbying, through the propagation of entirely imagined advantages over organic fertilizers, through the machinations of the bureaucracy’s old boy network, as well as the seemingly fortuitous end of the career of a politician who believed that foreign exchange should be reserved for industrialization rather than for fertilizers.

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<sup>3</sup> See for example, Devesh Kapur, John Prior Lewis, and Richard Charles Webb, (eds.) *The World Bank: Its First Half Century. Volume. 1: History* (Washington, DC, 1997), p. 387 and Esther Duflo, “Poor but rational?” in Abhijit Banerjee, Roland Benabou and Cilip Mookherjee (eds.), *Understanding Poverty* (Oxford, 2006).

Finally, I shall attempt to answer the question raised in Chapter 1; why were the dwarf wheat varieties adopted even though tall improved varieties could produce higher yields with lesser fertilizer. The adoption of the seeds was pressed by the Lyndon Johnson administration in the secret “Treaty of Rome” with India. I shall argue that in India, the choice was motivated on the one hand by enthusiasm for technological novelty. On the other hand marginalist analysis was central to decisionmaking and dwarf wheats produced higher *additional* yield for every additional unit of fertilizer than tall varieties even if total yield was lower. The real change in wheat production being sought by policy makers was to induce the cultivator to use higher fertilizer doses; once the switch to dwarfs varieties had been made, increased use of fertilizer was more profitable than it would have been with tall varieties. Thus while the new strategy was rhetorically based on the idea of universal peasant rationality, in practice, the model of the peasant that guided policy made more of his hunger for profit than his rationality in pursuit of that profit. Great store was set by the idea of making a psychological impact with demonstrations of super-normal (albeit inefficient) yields with the new seeds and high fertilizer doses.

The rhetoric of high science around the new seeds also served to justify larger changes in economic policy such as the shift in national priorities from industry to agriculture as well as the concentration of inputs and state aid to large farmers in favored regions. Capacity for state action in the countryside when it came to infrastructure, credit and extension was woefully limited; it thus perhaps made sense to rely for higher production on inefficiently high fertilizer use by a few farmers. Thus in practice, the rhetoric of *universal* peasant rationality was replaced by a focus on a few (mostly large) “progressive farmers”.

I

Nick Cullather provides a brief outline of the structuralist ideas that dominated development in the 1950s but does not mention the evolution of academic ideas and their impact on policy in the 1960s. While American aid to India always had a substantial bias in favour of agriculture, Cullather has outlined the political and Cold War-related strategic reasons which motivated America to further emphasize agriculture in its aid to India from the late 1950s onwards. He provides the customary outline of the efforts of the Johnson administration and of battles within the Indian establishment to get India to devote more resources to agriculture; but mentions the visit of the World Bank’s Bell Mission only in

passing. He, mentions the controversy over the “Treaty of Rome” but does not delve into the text of the treaty itself.<sup>4</sup> Francine Frankel has suggested that the World Bank mission played a significant role in policy formation, and that the new seed varieties enabled the Agriculture Minister to claim that his policies were grounded in science.<sup>5</sup>

That Green-Revolution policies placed the agency of the farmer at the centre of agricultural development efforts has been recognized by Gurcharan Das in his popular economic history of India. According to Das, Jawaharlal Nehru attempted an industrial revolution in India but failed due to his distrust of businessmen; instead, India later had an agricultural revolution by trusting the agency of the farmer.<sup>6</sup> That the Shastri years were characterized by a general liberalization of the economy has been recognized by Medha Kudaisya who has focused on industrial policy but outlined the souring of relations of the government with big business due to the setting up of the Food Corporation of India.<sup>7</sup>

Theodore Schultz’s “poor but efficient” theory is considered very significant by economists; the economist Esther Duflo writes that rejecting or accepting this theory means rejecting or accepting *all* the postulates of neoclassical economics.<sup>8</sup> The official history of the World Bank (written by public policy scholars) points out that while Schultz’s ideas were not particularly novel, his translation of old ideas into an economist’s terminology had a huge impact. The authors speculate on whether or not World Bank president George Woods had read the book before making a crucial speech which marked a turn of the Bank towards funding agricultural activities and go so far so far as to argue that Schultz “provided a scenario for the Green Revolution before the phenomenon even had a name”.<sup>9</sup> His contributions to the development of price theory, to the American farm subsidy policy and his general “development” consultancy assignments, particularly in

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<sup>4</sup> Cullather, *Hungry World*, pp. 146-158& 180-204.

<sup>5</sup> Francine Frankel, *India’s Political Economy: The Gradual Revolution* (Princeton, 1978), pp. 241-253.

<sup>6</sup> Gurcharan Das, *India Unbound: From Independence to Global Information Age* (New Delhi, 2000), p. 87-91.

<sup>7</sup> Medha M. Kudaisya, “‘Reforms by stealth’: Indian economic policy, big business and the promise of the Shastri years, 1964–1966”, *South Asia: Journal of South Asian Studies* (2002) 25:205-229.

<sup>8</sup> Duflo, “Poor but rational?” p. 367.

<sup>9</sup> Kapur *et. al*, *The World Bank*, p. 387.

Chile have been noted in a volume on the development of the Chicago School of Economics.<sup>10</sup>

In his critique of agricultural development theory, economist Terry Byres has briefly outlined how Schultizian ideas represented the first challenge to what he has termed “Old Neoclassical Development Economics” (usually called the Lewis structuralist model) which culminated in the Washington Consensus in the 1980s.<sup>11</sup> Ashutosh Varshney has credited Schultz with turning attention to agriculture as an engine of growth that came to dominate development theory.<sup>12</sup>

### **Postwar Development Theory and Practice**

Pioneers of postwar development theory such as Rodenstein-Rodan and John P. Lewis argued that neoclassical economics was irrelevant in the analysis of underdeveloped countries. Markets were imperfect, rural interest rates in informal markets were usurious, peasants did not respond to price movements and agrarian institutions were unsuited for inducing development as the relationship between economic agents was not necessarily mutually advantageous. Another key assumption of developmental economics was the theory of surplus labour which saw an almost infinite pool of unutilized labour in the rural Third World; within India this notion was strong amongst economists who thus felt that agricultural production could be massively increased by utilizing labour rather than increasing capital inputs. Industry, rather than agriculture was to be the engine of modernization.<sup>13</sup>

Before the mid-1960s, the primary goal allotted to the agricultural sector in India was to sustain the countryside and produce cheap food for a growing industrial workforce. There was considerable unease over what moved the cultivator; according to Nehru, “the basic problem facing India is that of the peasant. How do we change his mental outlook?”<sup>14</sup> In

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<sup>10</sup> Robert Van Horn, Philip Mirowski, and Thomas A. Stapleford (eds.), *Building Chicago economics: new perspectives on the history of America's most powerful economics program* (Cambridge, 2011).

<sup>11</sup> T.J. Byres, “Agricultural Development: The Dominant Orthodoxy and an Alternative View”, in Ha-Joon Chang (ed.), *Rethinking Development Economics* (London, 2003), p. 238.

<sup>12</sup> Ashutosh Varshney, “Introduction: Urban Bias in perspective”, *The Journal of Development Studies* (1993) 29:3-22.

<sup>13</sup> Byres, “Agricultural Development”, pp. 235-240.

<sup>14</sup> As quoted in Varshney, *Democracy*, p. 43.

particular, the controversy was about how the peasant would respond to high prices: would he produce more to make a profit, or would he produce less; either satisfied with maintaining the same profit with less effort, or fearing a crash in prices. The technocratic elite including the Planning Commission feared that the peasant would respond perversely to incentives; by justifying lower prices, this fear served their goal of concentrating resources on rapid industrialization. Thus India in the 1950s pursued a policy of ceiling, rather than floor prices.<sup>15</sup>

The national left elite sought to incentivize higher production on the cheap through institutional changes such as land reforms. In terms of technology, public irrigation was at the centre of the strategy and its role in risk mitigation which would encourage the farmer to adopt better cultivation fit in well with the perception of the farmer as a risk and investment-averse creature. Private irrigation too was encouraged on a small scale through programmes of difficult to avail loans and subsidies. Such was the perceived importance of irrigation that unlike other inputs, it was never suspected that the farmer would not use water. But the availability of expensive working inputs which required foreign exchange (most crucially fertilizers) was largely curtailed, while cheap inputs such as organic manures and a more intensive labour use was encouraged.<sup>16</sup> In any case, the government's ability to introduce technological changes that required of farmer the investment of fixed or working capital was limited, mostly by the thin spread of the state. "Community development" was the national rural policy but as late as the early 1960s, only about 60% of that system was functional.<sup>17</sup>

From the beginning, many influential Indians were against the squeezing of agriculture for industrialization; committee after influential committee recommended steps to improve agriculture through better prices. The state-level politicians who marshalled the political muscle defeated land reform legislation through indifferent implementation; they too favoured higher prices. Almost all of Nehru's Agriculture Ministers fell out with him, including KM Munshi, AR Kidwai, AP Jain and SK Patil, with the latter famously saying "whether it was Russia, America or India, experience has shown that any increase in

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<sup>15</sup> Varshney, *Democracy*, pp. 28-50.

<sup>16</sup> Varshney, *Democracy*, pp. 28-53.

<sup>17</sup> Carl C. Malone and Sherman E. Johnson, "The Intensive Agricultural Development Program in India", *Agricultural Economics Research* (1971) 23:28.

agricultural production could only be brought about through incentives to the individual.”<sup>18</sup>

### **How Senapur's *thakurs* shaped the World**

This political challenge was soon buttressed by an intellectual challenge as key ideas of this model began to be questioned; this challenge culminated in Theodore Schultz's 1964 book *Transforming Traditional Agriculture*.<sup>19</sup> Before outlining the development of Schultz's ideas, I shall outline the fieldwork done by a Canadian researcher W. David Hopper in India in the 1950s which became the basis of key Schultsian claims.

In 1954, William David Hopper, a Canadian student at Cornell University arrived in the village of Senapur in the Jaunpur district of eastern UP in pursuit of data for his Ph.D. on agricultural economics and cultural anthropology as a Social Science Research Council Area Training Fellow.<sup>20</sup> Hopper studied the operation of 43 farms, a sample he described as “close to random” but consisting entirely of upper caste *Thakur* land owners who “did not touch the plow”. Using farmer interviews, as well as actual measurement of field sizes, of irrigation water lifted by the *mot*, and human and bullock labour with a stopwatch, Hopper collected data on expected yield, and the input of land, labour and bullock time and irrigation water to agriculture.<sup>21</sup>

Hopper used this data to study how the farmer allocated resources to production alternatives (or crop choice). In keeping with the theory of marginal utility, if farmers had allocated the inputs to their production alternatives efficiently, the expected commodity price times the marginal yield from any input would be equal to the price of the input. However, none of the inputs (except labour) were purchased, so an implicit price had to be computed from the geometric mean of the data, expressed in barley (or other crop) equivalents. The condition signifying efficient allocation thus became that implicit prices of inputs derived from each crop was the same. The analysis produced a remarkably close correspondence; signifying to Hopper that the average allocation was “efficient within the context of the prevailing technical relationships”,

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<sup>18</sup> As quoted in Varshney, *Democracy*, p. 44.

<sup>19</sup> Theodore W. Schultz, *Transforming Traditional Agriculture* (New Haven, Ct., 1964).

<sup>20</sup> W. David Hopper, "Allocation Efficiency in a Traditional Indian Agriculture", *Journal of Farm Economics* (1965) 47:611.

<sup>21</sup> Hopper, "Allocation Efficiency", p. 613

It seems likely that in a technologically stagnant agriculture, farmers are intuitively aware of the resource substitution possibilities and the production responses of their agricultural enterprises. These are embodied in the lore of the culture transmitted from generation to generation, and are derived from refinements of techniques that arise from the observations and "experiments" made by past and present farmers. It is, therefore, not surprising to find relatively few allocation errors and a high level of production efficiency within the framework of the traditional state of the arts.<sup>22</sup>

A reflexive Hopper admitted many flaws in this analysis. Although he had standardized inputs for quality, they would "still depart from the neat precision implied in a static production model".<sup>23</sup> The discrete nature of the inputs was also an issue; land was unconsolidated and the average field measured just 0.37 acres. A labour hour varied from farm to farm as some landowners were obviously better supervisors than others. Labour was in shifts that varied with the task, and had a strong tendency to succumb to Parkinson's Law and spread the work out through the shift. Only cash and kind wages for specific labour services were taken into account and no attempt had been made to take harvest gifts and land given on low rent to particular responsible labourers into account.<sup>24</sup>

Another issue with the model was the constraint placed on free crop choice by the availability of irrigation. Wells, though privately owned were "virtually public resources"<sup>25</sup> which could be used by any farmer who took his place in queue. However, the well owner enjoyed the advantage of out of turn irrigation at will; this meant that wheat, locally perceived as a drought prone crop automatically got acreage preference on the well owner's land and farmers who didn't own a well found it optimal to reduce wheat acreage.<sup>26</sup>

Finally, only about 40% of the produce was sent to the market, so it was unclear what impact market prices had on decisions; but according to Hopper, market prices were important as they were central to most discussions in the village. Given these issues, the data needed to be regarded with extreme care. Hopper made it clear that he intended to

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<sup>22</sup> Hopper, "Allocation Efficiency", p. 613.

<sup>23</sup> Hopper, "Allocation Efficiency", pp. 611-624.

<sup>24</sup> Hopper, "Allocation Efficiency", pp. 611-624.

<sup>25</sup> Hopper, "Allocation Efficiency", p. 616.

<sup>26</sup> Hopper, "Allocation Efficiency", p. 616.

“ignore this caution” though he implored the reader to keep the same in mind while interpreting his results.<sup>27</sup>

There were issues in Hopper’s conclusions beyond the ones he admitted. The study had been carried out between September and December when the *kharif* crops were harvested and threshed while the *rabi* crops were sown and irrigated as it was expected that allocation decisions would be made on the basis of production response, input prices, and expected output prices at this time of “scarcity pressure on resources”.<sup>28</sup> There was however no reason to conclude that farmers would exhibit the same care in other seasons. Moreover, Hopper’s research gave no indication as to whether the entire stock of the identified resources such as labour and bullock power being used to the fullest extent of their availability. It is questionable whether the findings suggested that traditional agriculture was efficient in general. At best the farmers merely allocated their known resources to 4 different crops efficiently, and in no way did the findings suggest that (say) traditional wheat production was efficient in itself.

Hopper did not attempt to take his analysis too far or to forcefully suggest that his specific finding was a general trend; indeed while a footnote pointed that the conditions of Senapur were typical of the Indo-Gangetic plains, the title of his paper referred “*a* traditional Indian Agriculture” (emphasis added) rather than “traditional Indian Agriculture” or even just “traditional agriculture”.<sup>29</sup> While he finished his Ph.D. in 1957 and produced an early draft of this paper, it was only in 1965 that he published it in a journal, even as he continued to publish other work. Had he not presented his work at a seminar at the University of Chicago in 1957 where it was heard by Theodore Schultz, it is unlikely that the Senapur study would have made a major impact on the world of economics, let alone shape policy thinking as it did.

David Hopper later joined the Ford Foundation in India and was a very influential advisor on agricultural policy to the Government of India and played an important role in the evolution of the country’s New Agricultural Strategy.

### **Poor but Efficient?**

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<sup>27</sup> Hopper, "Allocation Efficiency", p. 617.

<sup>28</sup> Hopper, "Allocation Efficiency", pp. 611-624.

<sup>29</sup> Hopper, "Allocation Efficiency", p. 611.



Early intellectual critique of the postwar consensus in Third-World economic development came from Theodore Schultz and his students. Schultz was a South Dakota farmboy who earned a doctorate from the University of Wisconsin-Madison in 1930 on the theoretical aspects of the relationship between tariffs and feed grain production. He taught at the Iowa State College until 1943 after which he moved to the University of Chicago where he served as the chair of economics between 1946 and 1961, and became president of the American Economic Association in 1960.<sup>30</sup>

Schultz and his students began to work on Third-World agricultural development in the late 1950s. In 1961, Raj Krishna (an Indian student of Schultz) used Punjab as a case study in his Ph.D. thesis to argue that poor world farmers *were* rational and responded to price movements.<sup>31</sup> In the same year, Schultz used the case of the post First World War Influenza Epidemic in India (because of which urban India saw higher population growth than rural India) to argue against the theory of surplus labour. This foray into development economics culminated in 1964 with the publication 1964 of Schultz's influential book *Transforming Traditional Agriculture*.<sup>32</sup>

*Transforming Traditional Agriculture* was published as one in a series by The Inter University Committee on Comparative Economics with support from the Ford Foundation. According to the series foreword, "Comparative economics" had thus far consisted of a "botanical classification of national economies into a few loosely labelled boxes"; it was usually asserted "that "Western Economics" has only limited analytical value" in new nations struggling towards economic independence.<sup>33</sup> Schultz book challenged this and other ideas that then constituted the economic orthodoxy.

Schultz began,

The man who farms as his forefathers did cannot produce much food no matter how rich the land or how hard he works. The farmer who has access to and knows how to use what science knows about soils, plants, animals and machines can

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<sup>30</sup> *Encyclopædia Britannica Online*, s. v. "Theodore William Schultz", accessed August 24, 2015, <http://www.britannica.com/biography/Theodore-Schultz>

<sup>31</sup> Quoted in T.J. Byres, "Agricultural Development", p. 238. Also see Raj Krishna, "Farm Supply Response in India-Pakistan: A Case Study of the Punjab Region", *Economic Journal* (1963) **73**: 477-87.

<sup>32</sup> Schultz, *Transforming*.

<sup>33</sup> Abram Bergson, Arthur R. Burns, Kermit Gordon, Richard Musgrave, William Nicholls, Lloyd Reynolds, "Foreword" in Schultz, *Transforming*, pp. v-vi.

produce an abundance of food though the land be poor... the knowledge that makes this transformation possible is a form of capital.<sup>34</sup>

According to Schultz, transforming niggardly agriculture was about investment, and what was needed was an understanding of what form this investment must take. But economists and countries, had put agriculture aside in favour of industrialization. Economists lacked an understanding of agriculture, as studies of the same had been restricted to rich countries; there they had chosen to confront all manner of problems except the economics of growth. The study of traditional agriculture in poor countries had been left to anthropologists who had contributed little of use to policy.<sup>35</sup> According to Schultz, it was wrong to blame the niggardliness of traditional agriculture on cultural values relating to work, thrift, industriousness and aspirations for a better life when “a simple economic explanation would suffice”.<sup>36</sup>

He went on to propose that there were few inefficiencies in the allocation of the factors of production in traditional agriculture. This he did using two case studies; one of Panajchel in Guatemala by the anthropologist Sol Tax and David Hopper’s Senapur study. In what would become a very famous phrase, the latter, as yet unpublished (and shorn of Hopper’s many disclaimers) work was used by Schultz to claim that the farmer

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<sup>34</sup> Schultz, *Transforming*, p. 3.

<sup>35</sup> This was a stark misunderstanding on Schultz’s part, for the economics of agriculture had been long studied in India; there were enough professionals as early as 1939 to form an Indian Society of Agricultural Economics and some of India’s finest minds had applied themselves to the problem. Besides research within universities, in the early 1950s India had set up a network of Agro-Economic Research Centres to explore the regional dimensions of agricultural economics. Many Indians went abroad to study the discipline, some on government scholarships; indeed there were several articles in farm economics journals on how to best train this new deluge of students from developing countries. See for example Kenneth H. Parsons, "U.S. Training for Foreign Students in Agricultural Economics", *Journal of Farm Economics* (1957) 39:235-249. Schultz himself had guided at least 2 students who worked on topic related to Indian agriculture before writing the book; Uma Lele, who left to continue her studies at Cornell and the aforementioned Raj Krishna who obtained his Ph.D. on the economics of farming in Punjab in 1961 and famously coined the phrase “Hindu Rate of Growth” to describe the Indian economy under the license-permit-quota *raj*. Indeed when Schultzian ideas were applied in India, there would be a large contingent of Indian agricultural economists well qualified to evaluate them. See for example, V. M. Dandekar, "Transforming Traditional Agriculture: A Critique of Professor Schultz", *Economic and Political Weekly* (1966) 1:25-36 and S. N. Mishra, "Transforming Traditional Agriculture: Comments on Dandekar's Critique of Schultz: I", *Economic and Political Weekly* (1966) 1:799-802.

<sup>36</sup> Schultz, *Transforming*, p. 7.

in the developing country was “poor but efficient” (Guatemala was “very poor but efficient”). Schultz found it “not feasible” to show that these two villages were typical of the poor world but as his thesis was a “proposition likely to be widely useful”,<sup>37</sup> he went on to develop its implications, two of which were very significant. As farmers were rational, they would respond to high prices by producing more and adopting profitable new technologies. The second was that given diminishing marginal returns, as traditional factors were already being used to the optimum, cheap growth in agriculture could only come from modern inputs that would come from research. Plant breeding was particularly important and he gave the example of the work being done by the Rockefeller Foundation.<sup>38</sup>

In Schultz’s prescription, investment in human capital was important; education would enable farmers to use new technology. Beyond this more general point, it was important to increase the stock of highly skilled workers such as scientists. Old Ricardian ideas about land had been rendered irrelevant; land was “over rated” and through research, “substitutes for cropland” could be discovered.<sup>39</sup> Investment in human capital was thus important to increase the agricultural research capacity of nations. As agricultural firms were too small for individual research, investment in science was the responsibility of the state.<sup>40</sup>

As I will show, these ideas about incentives for a profit-maximizing farmer, and agricultural science to enable that profit proved to be very influential in the formulation of the New Agricultural Strategy in India. The Agriculture Secretary B. Sivaraman would claim that the New Agricultural Strategy was based on “basic assumptions about human motivations”; that the peasant was moved by a rational drive for profit.<sup>41</sup>

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<sup>37</sup> Schultz, *Transforming*, p. 123.

<sup>38</sup> Schultz, *Transforming*, p. 141.

<sup>39</sup> See Theodore W. Schultz, "The Economics of Being Poor", Nobel Prize Lecture, 1979, [http://www.nobelprize.org/nobel\\_prizes/economic-sciences/laureates/1979/schultz-lecture.html](http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/1979/schultz-lecture.html) accessed online on 17th February 2015.

<sup>40</sup> Schultz, "Being Poor".

<sup>41</sup> B. Sivaraman, *Address by Shri B. Sivaraman on Collector's Role in Indian Agriculture at the National Academy of Administration, Mussoorie, on 14th May, 1970* (New Delhi, 1970), p.7.

### **A New Agricultural Policy for India**

In the mid-1960s, India's agricultural policy saw a drastic change. Floor, rather than ceiling prices were introduced and the high prices were to largely go to the farmer; the money was to come partly from higher consumer prices and partly from state subsidies through heavy management of the foodgrain economy. These policies were largely implemented in regions where the state machinery was well developed. Within these areas, this policy, which rested on expensive inputs and private capital investment was targeted largely at big farmers. How did this change come about?

The 1960s was time of economic crisis in India. With just one plan (the second five year plan) having been substantially formulated by the Planning Commission and completed, planning in India began to fall apart. There were several reasons for this. Based on a promise from the World Bank, the Third Plan had placed a substantial reliance on foreign aid (30% of the outlay compared to 10% in the First Plan and 24% in the Second Plan); this was not forthcoming. The 1962 war with China and the 1965 war with Pakistan had led to a doubling of defence expenditure as a proportion of GDP from 2% to 4%. Such were the pressures on public finances that the years between 1966 and 1969 saw a "Plan Holiday" when long-term planning itself was suspended.<sup>42</sup>

Agriculture remained weather dependent, and the early 60s saw severe drought. There was a drought in 1961-62 but a year of good monsoon in 1964-65 brought foodgrain production to an all-time high of 89 million tonnes. The next two years saw severe drought which reduced production to 72.3 and 75.9 million tonnes respectively.<sup>43</sup> The prediction of the 1959 Ford Foundation Report *India's Food Crisis and Steps to Meet It*, which argued that population growth would outstrip food production<sup>44</sup> appeared to be coming true.

In addition to this economic crisis, there was much political instability at the highest levels of government. Nehru passed away in 1964 and was succeeded by Lal Bahadur Shastri who did not share his industry-first bias and was amenable to the pressures of state

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<sup>42</sup> See Banerjee, *Economic Planning*, pp. 83-102.

<sup>43</sup> From Directorate of Economics and Statistics, *Estimates of Area, Production and Yield of Principal Crops in India* (New Delhi, 1970).

<sup>44</sup> Agricultural Production Team (Ford Foundation) and Ministry of Food and Agriculture, *Report on India's food crisis & steps to meet it* (New Delhi, 1959).

bosses and big business. After less than two years at the helm, Shastri too passed away and Indira Gandhi took over. Shastri appointed C. Subramaniam as Agriculture Minister; appointed at a time of crisis, even Subramaniam feared he had fallen into a political trap set by the Prime Minister, for the portfolio “had been the Waterloo” of many a political career.<sup>45</sup>

Chidambaram Subramaniam was a Madras politician who had started his national career in 1962 when Nehru had appointed him to the Steel Ministry. He had been known for making “technocratic” decisions in that position, for example by appointing engineers rather than bureaucrats to head steel plants. According to Subramaniam, having previously worked with industry, he was able to look at agriculture from a new perspective. No industry could succeed if it was not profitable, and he came to the conclusion that agriculture was a losing proposition for the farmer as a result of price policies put in place during the Second World War. Consequently, most investment in agriculture, (such as irrigation) had been made by the government rather than the private sector. He proposed a “radical change in price policy” which was opposed by the finance minister TT Krishnamachari who remained suspicious of high prices and favoured “other incentives”.<sup>46</sup> The PM appointed LK Jha, the Cabinet Secretary to go into the matter and a 15% increase in prices was agreed to in October 1964. More crucially, a permanent Agricultural Prices Commission was set up in January 1965 to determine a fair incentive price for rice and wheat taking the cost of cultivation;<sup>47</sup> this has played the role of (officially at least) an independent expert arbiter between urban-industrial and rural-agricultural interests since then. An early member of the Commission was Schultz’s aforementioned student Raj Krishna who had just returned to India.

If indeed there was a food crisis in India, the second change that Subramaniam brought about did more to solve it than perhaps any other technology or policy change of the Green Revolution. According to him, a price policy had no meaning if the state’s physical capacity to trade in the market was limited; farmers were under pressure to sell at low prices right after the harvest, so traders were in a position to depress prices. A Food Corporation of India (FCI) was set up in 1965 with an initial mandate to procure at least

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<sup>45</sup> Chidambaram Subramaniam, *New strategy in Indian Agriculture: The First Decade and After* (New Delhi, 1979), p. 7.

<sup>46</sup> Subramaniam, *New strategy*, p. 14.

<sup>47</sup> Subramaniam, *New strategy*, pp. 3-20.

10% of the output. The target took some time to meet, as the logistical infrastructure took time to build; in fact a new company called the Central Warehousing Corporation had to be set up to design and build storage. In the case of rice, modern rice mills also had to be set up at the FCI's initiative. These measures "became necessary as a chain", one after the other.<sup>48</sup> Despite these difficulties, the procurement of food grains increased from 1.43 million tonnes in 1964 to 4.03 million tonnes in the next year,<sup>49</sup> a statistical leap unparalleled by any production growth.

The veteran journalist Prem Shankar Jha gives an interesting account of early procurement operations. The government would target certain districts and even entire states such as Punjab, and would throw a security cordon around them at harvest time to prevent grain from moving out. Prices fell as a result, and the government could easily buy much of the produce from the farmer at a price that was low but much higher than what they would have gotten from private traders. By 1971, a fifth of the total wheat production was being purchased by the government.<sup>50</sup> The FCI soon became one of the world's largest logistical operations; in 2008-09, the FCI and state agencies procured nearly 33 million tonnes of paddy, 23 million tonnes of wheat and 14 million tonnes of coarse grains.<sup>51</sup>

The procured foodgrain was to provide for a buffer stock against price fluctuations and to be sold in cities and deficit areas at a reasonable price; this entailed heavy subsidies. In the late 1970s, wheat was procured at Rs. 200 per ton and rice at Rs. 100. Distribution costs varied between Rs. 148 and Rs. 234 per tonne. To keep grain cheap, the FCI received a consumer subsidy of between Rs. 246 and Rs. 298 per ton while selling to the state governments. This was in addition to a reimbursement of the cost of carrying a buffer stock for bad years of about Rs. 250 per ton.<sup>52</sup> In addition, some state governments

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<sup>48</sup> Subramaniam *New strategy*, pp. 23-25.

<sup>49</sup> Biplab Dasgupta, *The New Agrarian Technology and India* (London, 1977), p. 68.

<sup>50</sup> Prem Shankar Jha, *India: A Political Economy of Stagnation* (New Delhi, 1980), p. 33-34.

<sup>51</sup> Anon., *Selected State-wise Procurement of Rice, Wheat and Coarse Grains in India*, accessed online on IndiaStat website at <http://www.indiastat.com/table/agriculture/2/foodgrains/17786/774579/data.aspx> on 10th August 2015.

<sup>52</sup> P. S. George, *Aspects of Public Sector Procurement and Distribution of Foodgrains in India* (Washington, DC, 1985), p. 83.

introduced their own subsidies while selling to the consumer through the ration shops of the Public Distribution System (PDS).

As is well known but not adequately emphasized, the procurement of grain for the cities from the countryside and distributing it cheap was at least as important a problem as production alone. The PL 480 food aid that India got from the United States from the mid-1950s onwards had thus been extremely important not just in the quantities it supplied but also in the fact that it was entirely within the government's control and could form the backbone of rationed supply in the cities.<sup>53</sup> It was not just increased production but also the setting up of the FCI which enabled India to dispense with imports altogether by 1975.

From the late 1970s onwards, cheap government grains started making their way to the rural poor as well, initially through specialized food-for-work programmes and later, through the gradual ruralisation of the PDS itself. Such programmes provided significant (albeit limited) security to the rural poor as real their incomes declined in large parts of India.<sup>54</sup> Significantly, in 1980 Jimmy Carter's Presidential Commission on World Hunger would note that India was the "only developing country in the world which has built a solid system of *food security*";<sup>55</sup> emphasizing the more complex idea of food security rather than increased production alone.

### **Technology and the New Strategy**

In his account of the New Agricultural Strategy, it is only after the discussion of these two crucial steps, followed by the food import policy does Subramaniam come to science, though it takes up most of the rest of the book. He called for scientists from the Indian Agricultural Research Institute and spoke of the encounter in his first public speech as Agriculture Minister at an agricultural university in his hometown, Coimbatore,

I heard a tale of woe that the agricultural scientists were considered as second class or third class scientists and therefore their scales of pay and their status was only on that level. This would naturally mean that second class or third class

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<sup>53</sup> Nilakanth Rath and V.S. Patvardhan, *Impact of Assistance under PL 480 on Indian Economy* (Pune, India, 1967), p. 13.

<sup>54</sup> Utsa Patnaik, "Some Economic and Political Consequences of the Green Revolution in India" in Henry Bernstein, Ben Crow, Maureen Mackintosh, & Charlotte Martin (eds.), *The Food Question: Profits vs. People?* (London, 1990), pp. 86-87.

<sup>55</sup> As quoted in Das, *India Unbound*, p. 91. Emphasis mine.

scientists alone would come to the agricultural scientists' position. Therefore I immediately asked department to put up proposals for the revisions of the scale of pay of the agricultural scientists' ... My attempt has thus been to give a new status and the recognition of that status to agricultural scientists...<sup>56</sup>

There is thus no indication that scientists proposed any revolutionary or gradual technologies to Subramaniam which had been resisted by the political class earlier; in fact Subramaniam was inadvertently suggesting that they were “third class scientists”. Subramaniam indeed did much to reorganize agricultural science in India and to give it “a new status”. But by his own account as mentioned in Chapter 1, it was Dr. Ralph Cummings of the Rockefeller Foundation (which had developed the technology) who brought him “the message of the new seeds” in October 1964, complaining that Indian scientists were resisting the spread of these seeds to the farmers’ fields.<sup>57</sup>

In terms of expensive new technology, fertilizer was really the kingpin. It was to study the problems of fertilizer distribution in early 1965 that Subramaniam first brought in fellow Tamil B. Sivaraman. An IAS officer of the Orissa cadre, he was soon elevated to the position of Agriculture Secretary and was to play a central role in India’s agricultural policy. Fertilizers distribution had thus far been the monopoly of cooperatives and according to Sivaraman, much of their quota was diverted into the black market; cooperatives “were as liable to black markets as free market systems”. He recommended an end to the monopoly, confident that establishing a new privately-led system would expose the ineffectiveness of the cooperative system.<sup>58</sup> As I will show, perceived inefficiencies and corruption of public and community institutions was central to other policy changes as well.

To establish that chemical fertilizers were better than organic ones was a difficult task. Writing in 1979 nearly a decade and a half after the New Strategy was introduced, the only argument that Subramaniam could come up with was that more tonnes of waste would be required than available. In addition, timing of fertilizer application was important in high-yielding agriculture; while several tonnes could be applied before sowing, applications of such a large mass later in the growth cycle would “drown the

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<sup>56</sup> Subramaniam, *New strategy*, p. 37.

<sup>57</sup> Subramaniam, *New strategy*, p. 40.

<sup>58</sup> B. Sivaraman, *Bitter Sweet: Governance of India in Transition: Memoirs of B. Sivaraman* (New Delhi, 1991), pp. 273-274.



crop”.<sup>59</sup> This was a specious argument, for countries with an animal-to-land ratio lesser than India’s had managed to raise production through the careful conservation of all waste; both the Chinese and the Japanese managed to apply much organic fertilizer throughout the plant growth cycle without drowning the crop.<sup>60</sup> In any case, the intense study of the agronomy of dwarf wheat in the late 1960s would show that at low fertilizer dosages, a single dose at sowing time was more effective than a split one, and at very high doses, the loss in yield due non-optimal timing was less than 10%.<sup>61</sup> It is questionable whether such a low difference in yields was worth the massive disruption that fertilizer imports were expected to cause in the Indian economy.

Sivaraman was faced with the task of creating a political atmosphere in favour of fertilizer imports to influence the Finance Minister TT Krishnamachari to release foreign exchange; the latter was of the view that precious foreign exchange should be reserved for industrialization. His efforts were not helped by the widely held view that organic manures were not only cheap but also better as long as the farmer could be convinced to use them. Sivaraman was incensed that the UP government invited MS Sivaraman, an older IAS officer to lecture on the benefits of green manure; this apparently proved a great hindrance. To B. Sivaraman, MS Sivaraman was a perfect example of "experts who had established their credentials long ago in their field but had lost their capacity to advice by failing to update their knowledge and basking in past achievements".<sup>62</sup> To create a favourable atmosphere, Sivaraman fell back on the IAS old boy network. He told Manzur Alam Quereishi, the Development Commissioner of UP to “coach” a group of provincial legislators on the merits of chemical fertilizers and take them to see Prime Minister Shastri. At the same time, he rung up the Prime Minister’s secretary LK Jha, told him about the fertilizer problem. The latter told him to prepare a note and appear before the cabinet; this apparently breached the protocol on how notes were taken to the cabinet. Fortuitously for Sivaraman and Subramaniam, TT Krishnamachari’s political career ended over a minor corruption scandal within weeks.<sup>63</sup> The new Finance Minister Sachindra Chaudhuri, a man who had previously held no ministerial position, was, by

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<sup>59</sup> Subramaniam *New strategy*, p. 79.

<sup>60</sup> Kusum Nair, *Transforming Traditionally: Land and Labor in Agriculture in Asia and Africa* (Riverdale, Md., 1983), p. 30-42.

<sup>61</sup> Khem Singh Gill, *Research on Dwarf Wheats* (New Delhi, 1979), p. 142.

<sup>62</sup> Sivaraman, *Bitter Sweet*, p. 276.

<sup>63</sup> B. Sivaraman, *Bitter Sweet*, pp. 274-278.

Subramaniam's account, "more open to influence".<sup>64</sup> Sivaraman got the necessary foreign exchange allocation for fertilizer, while his minister remained a silent spectator, having smelt that political intervention "would be fatal."<sup>65</sup> Thus the basic elements of a new agriculture, with higher prices as incentive and fertilizer as technology, together with a system of procurement was in place by late 1965.

### **The Bell Mission**

The Subramaniam-Sivaraman account of the agricultural policy changes predictably emphasize that the new ideas came from within the government of India (mostly themselves). But western economists employed by USAID and the Ford and Rockefeller Foundations in India were influential policy advisors; so influential in fact that by Sivaraman's own account, C Subramaniam had selected him at the advice of the Ford Foundation.<sup>66</sup> These experts were often consulted on everyday matters; for example as mentioned in Chapter 1, when Indian economists produced a devastating public critique of the fertilizer allocation policy, it was to David Hopper that Sivaraman turned to for advice on the government's response. Both Subramaniam and Sivaraman formed lasting friendships with foreign advisors; Subramaniam's account of the New Agricultural Strategy's evolution was written as a research visitor at the Australian National University at the invitation of its Vice Chancellor J.G. Crawford who wrote the foreword to the book and B. Sivaraman also mention his close friendship with Crawford in his memoirs.<sup>67</sup> An Australian economist and civil servant, Crawford had first met Subramaniam and Sivaraman as the head of the agricultural team of the Bell Mission, an important group of experts sent by the World Bank to study India's economic development effort. Other members included Wolf Ladejinsky, an eminent American land reform specialist, L. Garnier and Louis Goreaux of the FAO in addition to David Hopper. The team spent many months in India in 1964-65 just as Subramaniam was cutting his teeth in his new portfolio; according to Francine Frankel, he was impressed by their recommendations which played an important role in policy formation.<sup>68</sup>

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<sup>64</sup> Chidambaram Subramaniam *New strategy* p. 51.

<sup>65</sup> B. Sivaraman, *Bitter Sweet*, p. 277.

<sup>66</sup> B. Sivaraman, *Bitter Sweet*, p. 271.

<sup>67</sup> Sivaraman, *Bitter Sweet*, p. 410.

<sup>68</sup> Francine Frankel, *India's Political Economy: The Gradual Revolution* (Princeton, 1978), p. 243.

While the primary objective of the Bell Mission was to appraise the upcoming Fourth Five Year Plan, the study was motivated “by the fact that all is not well with the Indian development effort”,<sup>69</sup> reflecting the growing sense of India as a basket case. Preparatory as the fifteen volume report might have been to the subsequent events such as the devaluation of the rupee, an IMF bailout in 1966, a general liberalization of the economy and the suspension of Five Year Planning itself for three years due to a state of economic emergency, it drew attention to the fact that agriculture above all had the potential to make or break the development of the other sectors; reflecting the new primacy of agriculture, rather than industry in development thought.

The mission had to first prove that Indian agriculture was a poor performer. Official statistics put the rate of growth of foodgrain output in the 1950s at an impressive 4%. Casting aspersions on the nature of the data, the mission assessed the growth rate to be much lower; David Hopper wrote an extensive appendix to statistically test the hypothesis that “growth is declining” which left him with a “profound sense of pessimism”.<sup>70</sup> The real extent of Hopper’s pessimism is unknown; in a 2004 oral history transcript, he said that Indian states of the era actually *under-reported* production to lobby for central government largesse.<sup>71</sup> This creation of a sense of crisis by western experts had actually

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<sup>69</sup> Bernard R. Bell, *Report to the President of the International Bank for Reconstruction and Development and the International Development Association on India’s Economic Development Effort*, Volume 1, *Main Report* (Washington, DC, 1965), p.ii. Accessed online at <http://documents.worldbank.org/curated/en/1965/10/12648064/report-president-international-bank-reconstruction-development-international-development-association-indias-economic-development-effort-vol-1-14-main-report> on 23rd February 2015.

<sup>70</sup> W. David Hopper, “The Statistical Record” in Bernard R. Bell, *Report to the President of the International Bank for Reconstruction and Development and the International Development Association on India’s Economic Development Effort*, Volume 3, *Agricultural policy : appendices I - V* (Washington, DC, 1965), pp. I-1 – I-42. Accessed online at <http://documents.worldbank.org/curated/en/1965/10/12648074/report-president-international-bank-reconstruction-development-international-development-association-indias-economic-development-effort-vol-3-14-agricultural-policy-appendices-v> on 23rd February 2015

<sup>71</sup> World Bank, *World Bank Group Archives oral history program: Transcript of oral history interview with W. David Hopper held on April 2 and May 12, 2004* (Washington, DC, 2004). Accessed online at <http://documents.worldbank.org/curated/en/2004/05/23023468/transcript-oral-history-interview-w-david-hopper-held-april-2-may-12-2004> on 28th July 2014.

begun at least as early as 1959 with the Ford Foundation report ominously titled *India's Food Crisis and Steps to Meet it*.<sup>72</sup> Daniel Thorner, an American economist who had ended up in India as a result of a McCarthy era job loss said that a reading of the report might give one the erroneous notion that India was facing a famine of the 1876-78 scale. To him, the Ford Team's was a "strategy of terror" designed to create a "statistically contrived food crisis" in order to shatter public confidence; one that would kill Indian industrialization by forcing it to turn "lathes into ploughshares".<sup>73</sup>

Having established that there was a crisis, according to the World Bank mission, its larger cause was the fact that since planning had begun, the terms of trade had moved against the farmer; this was exemplified with the cost of nitrogenous fertilizer. It extolled the benefit of high floor prices and argued against controlling prices by fiat. It saw the immediate crisis of high consumer prices as driven by short term speculation and consumer behaviour and argued for the creation of a buffer stock to increase consumer confidence. But the report was less focussed on food alone and called for floor prices to operate in the cash crop economy as well, to mitigate the risk of a shift in the cropping pattern away from cash crops and recommended that floor prices operate there as well.<sup>74</sup> As I showed in Chapter 1, there was indeed a shift away from cash crops, but an equally crucial factor in increasing food production was be a shift within the foodgrain sector towards wheat became the most remunerative crop.

Fertilizer being most important short term factor, the mission called for a subsidy to incentivize fertilizer use. Impressed by the ability of the Indian farmer to innovate by adopting fertilizer, the report quoted a lecture given by Hopper and argued that contrary to the assumptions of the social science literature on India, Indian farmers would be

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<sup>72</sup> Agricultural Production Team, *India's food crisis*.

<sup>73</sup> Daniel Thorner, "Ploughing the Plan Under: Ford Team Report on Food 'Crisis'", *Economic Weekly* (1959) **XI**: 901-904.

<sup>74</sup> Bernard R. Bell, *Report to the President of the International Bank for Reconstruction and Development and the International Development Association on India's Economic Development Effort, Volume 2, Agricultural Policy* (Washington, DC, 1965), p. 34.

Accessed online at

<http://documents.worldbank.org/curated/en/1965/10/12648065/report-president-international-bank-reconstruction-development-international-development-association-indias-economic-development-effort-vol-2-14-agricultural-policy>

responsive to scientific methods; if the Indian cultivator had not taken to scientific agriculture, the answer lay in more scientific research and inputs.<sup>75</sup>

The report quoted Schultz's very recent book on the differences in productivity between Japan and India. By its estimate, a growth rate of 2.5-3% was achievable by modest increases in fertilizer and irrigation. But to reach 5% or more as Indian planners targeted, there had to be a "many sided technological advance" through larger application of science and technology.<sup>76</sup> It was not quite clear in the report what this new technology was to be. While the development of new fertilizer responsive varieties suitable for Indian conditions was to be an important outcome of research, the report also emphasized better water management, as well as high quality seeds of existing varieties.<sup>77</sup>

### **The Treaty of Rome**

Besides the influential advice of these economists, there were other external pressures pushing for greater resources to be devoted to agriculture. India's need for food imports was used by Lyndon Johnson to shape her agricultural policy, by (among other things) committing only to monthly, rather than annual grain shipments; India was living "ship to mouth." The American pressures culminated in a secret agreement between C. Subramaniam and Orville Freeman, the American Secretary of Agriculture at the side lines of an FAO meeting in November 1965; this was the famous "Treaty of Rome". Arguing that there was a "disturbing downward trend" in per capita food production, the document required the Fourth Five Year Plan to double the investment in agriculture. The text of the treaty went so far as to specify that Prime Ministerial speeches were "to dramatize and mobilize public sentiment to demonstrate the urgency of action in agriculture".<sup>78</sup> This indeed happened within weeks when Shastri coined the slogan "Jai Jawan, Jai Kisan" (Victory to the Soldier, Victory to the Peasant) during the India

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<sup>75</sup> Bell, *Volume 2*, p. 42.

<sup>76</sup> Bell, *Volume 2*, p. 38.

<sup>77</sup> Bell, *Volume 2*, p. 39.

<sup>78</sup> Telegram from the American Embassy in Italy to the Department of State dated 26<sup>th</sup> November 1965. Accessed online at <https://history.state.gov/historicaldocuments/frus1964-68v25/d253> on 17th February 2015.

Pakistan war of 1965 which historians have seen as a crucial linking of food with national security which greatly enthused the nation.<sup>79</sup>

Fertilizer policy was at the core of the treaty which required the government to publicly endorse an ambitious five year target for fertilizer consumption. To stimulate private investment in fertilizer production, the government was to commit to buy any excess production at world market prices. It was to reduce its monopoly on fertilizer supply and distribution was also to be left in private hands. Procedural modifications were to be made in the process of licensing foreign fertilizer firms to shorten the time required for negotiations, and a Prime Minister led cabinet level committee was to deal with bureaucratic hurdles in licensing. Government participation in fertilizer ventures was to be made non-mandatory.<sup>80</sup>

When news of a secret treaty was leaked to the Indian press, Subramaniam claimed that these were steps that the government was already taking and the Treaty was merely Lyndon Johnson's way of showing Congress that he was turning the screws on India.<sup>81</sup> This was true to a large degree. But it is important to emphasize that the treaty merely set in stone what the Americans had been long pressing for, and it is likely that US pressure played a more important role in policy events than Subramaniam was willing to admit. For the treaty had many specific and detailed clauses; among them were commitment to the new seeds.

The treaty specified that 32 million acres "of the most productive land farmed by the more efficient farmers" was to be devoted to "new fertilizer responsive varieties" which were to be planted on the "best irrigated land" applying 100 to 150 pounds of fertilizer per acre; this land was to get fertilizer even if cutbacks were required in other areas.<sup>82</sup> As I showed in Chapter 1, influential Indian scientists and economists provided good reasons against both the adoption of the new varieties and the concentration of all fertilizer on them; and it is likely that American pressure played an important role in riding roughshod over all objections.

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<sup>79</sup> See for example Perkins, *Geopolitics and the Green Revolution*, p. 261.

<sup>80</sup> Telegram from the American Embassy

<sup>81</sup> Subramaniam *New strategy*, p. 97.

<sup>82</sup> Telegram from the American Embassy.

### The psychological Impact

But American pressure was not the only reason for the choice of the inefficient dwarf varieties. The plant breeders were understandably obsessed with high yields. This was not just about a technical achievement; Norman Borlaug wanted to achieve a psychological impact to shake the Indian peasant of his old ways with demonstrations “spectacular and shocking to both farmers and government officials”,

We want to kill old ideas and methods, and substitute dynamic new methods in one stroke. We want these first semi-commercial demonstrations to be so shocking that they will destroy old ideas of wheat production at one sweep.<sup>83</sup>

Indian scientists such as Dr. Satya Prakash Kohli, the co-ordinator of the All India Wheat Improvement Programme also set great store by “psychological considerations” as he revealed in a 1969 interview. According to Kohli, there had been a “hot debate” between scientific “hawks” and bureaucratic “doves”. While the latter wanted to merely go in for fertilizers without the HYVs and spread the gains over a large area, the former wanted to concentrate both in a small area with assured irrigation and “progressive farmers”. The hawks were motivated by “psychological considerations”; spectacular results would convince “the most tradition bound farmer that his small holding could give him a decent standard of living, provided he was ready to follow the new strategy”.<sup>84</sup>

This psychological impact was orchestrated by heavy propaganda. Farmers on the rural fringes of Delhi were said to have produced implausibly high yields not even achieved on research plots; Pandit Govardhan allowed demonstrations on his one hectare plot which netted him Rs. 5000 with a reputed yield of six tonnes as against a normal two, and Mahendar Pal Singh became a *lakhpati* by “gambling” with planting his entire 126 hectare holding with Mexican seeds and harvesting a *world* record yield of 8.4 t/ha.<sup>85</sup> They

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<sup>83</sup> As quoted in Madhumita Saha, *State policy, agricultural research and transformation of Indian agriculture with reference to basic food-crops, 1947-75* (Unpublished Ph.D. Dissertation, Iowa State University, 2012), p. 210.

<sup>84</sup> P.R. Gupta, “The Golden Revolution: Dr. SP Kohli talks about new seeds of prosperity”, *Times of India* dated January 26<sup>th</sup> 1969.

P.R. Gupta, “The Golden Revolution: Dr. SP Kohli talks about new seeds of prosperity”, *Times of India* dated January 26<sup>th</sup> 1969. . The yield figure for Mahendar Pal Singh’s farm, as well as its being seen as a world record is taken from Madhumita Saha, *State policy*, p. 212. *Lakh*=100,000 and the word *lakhpati* is used in Hindi to imply a millionaire.

became overnight celebrities visited by VIPs and journalists (and Dr. Borlaug). Such high yields needed the new seeds to even be believable; as Dr. M. S. Swaminathan tellingly wrote in 1967, had a student of agriculture answered 50 *maunds* (1850 kg/ha) when asked in 1963 about how high wheat yields could be, the college principal would have failed him. But with the new varieties, he would not be able to dismiss the answer even if the student answered 150 *maunds* (5550 kg/ha).<sup>86</sup> Attaining the spectacular was seen as important, as Dr. Borlaug noted in 1969,

Such spectacular increases in yield destroy, in one stroke, the built-in conservatism or resistance to change that has been passed on from father to son for many generations in a system of traditional agriculture. Such news spreads fast. It is now clear that the rate of adoption of new technology into a traditional agriculture is directly proportionate to the magnitude of yield change demonstrated, assuming a favourable price-cost relationship.

The importance of this psychological factor has been overlooked previously by scientists, economists, planners, extension specialists and top government officials. In the early stages of making the transplant, the plant scientists were forced to justify before "economic sociologists" the use of 120 pounds of nitrogen per acre on 400,000 acres rather than 40 pounds on 1,200,000 acres. This battle of resource allocation was won and the strategy saved ten years in the spread of new wheats and the new technology.<sup>87</sup>

The simplicity of this idea of a rational, hungry-for-profit farmer was particularly seductive for policy makers as William Gaud, the USAID administrator who had coined the term "Green Revolution" crudely put it,

The normally complicated business of development - how to get a country to develop, how to get people to change their attitudes- suddenly came down to a very simple proposition: one man seeing his neighbour doing better than what he was doing.<sup>88</sup>

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<sup>86</sup> *Indian farming*, August 1967.

<sup>87</sup> Norman Borlaug, Ignacio Navarez, Oddvar Aresvik and R. Glenn Anderson, "A Green Revolution Yields a Golden Harvest", *Columbia Journal of Business Affairs* (1969) 5: 9-19.

<sup>88</sup> As quoted in Kusum Nair, *Transforming Traditionally: Land and Labor in Agriculture in Asia and Africa* (Riverdale, Md., 1983), p.67.



The real motive of course was to popularize fertilizers; as Dr. Borlaug wrote to the representative of a Rockefeller group fertilizer company, the farmers of the developing world “would soon start clamouring for fertilizers”.<sup>89</sup> Kohli credited Dr. M.S. Swaminathan and Dr. B.P. Pal with convincing the doves and the new strategy committed the government to large-scale imports large of fertilizer; this he termed a fitting example of the “interaction of science with politics”.<sup>90</sup> Of course, the new Agriculture Minister C. Subramaniam had always been an enthusiast for a technocratic agricultural strategy and it is unlikely that the new seeds played an important role in the fertilizer import strategy. The new seeds also did not prove to be a stepping stone for farmers to start using fertilizers; for example, Bihar had as much area planted to HYV wheat as Punjab by the early 1970s, but the total fertilizer consumption in the late 1970s was less than what the single Punjabi district of Ludhiana consumed way back in 1965.<sup>91</sup>

Starting from a low base, the dwarf varieties had a steep curve of yield versus fertilizer dosage while tall varieties started from a high base, and a thus had less steep curve. If one were measuring the marginal return to fertilizer application rather than the total yield for a given dosage, the same would be higher for the dwarf wheats. Hence once the farmer was convinced to adopt the dwarfs, every additional unit of nitrogen would be extremely profitable, incentivizing the use of fertilizer; even as higher yields could be achieved with tall Indian varieties. And persuasion to use the dwarf varieties in at least some cases amounted to coercion; in a rice-growing district, researchers found that the supply of subsidized fertilizer was made contingent on a commitment to cultivate HYVs and it is likely that this was a widespread practice.<sup>92</sup>

Abstract studies of profitability from the period would usually focus on the marginal return rather than the total yield and hence did not shed light on the issue. Even so, strangely a Rockefeller Foundation funded study of wheat production in Punjab during the miracle 1967-68 crop year found that the marginal product of fertilizer application to old wheat was thrice as high as the new wheats. This was quickly explained away as suggestive of a “yield ceiling”; the “seemingly unreasonable” figure was not to denote

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<sup>89</sup> As quoted in Madhumita Saha, *State policy*, p. 213.

<sup>90</sup> Times of India January 26<sup>th</sup> 1969.

<sup>91</sup> For a comparative study of wheat farming in Punjab and Bihar, see Kusum Nair, *In Defense of the Irrational Peasant: Indian Agriculture after the Green Revolution* (New Delhi, 1979).

<sup>92</sup> *Green Revolution?: The Impact of High Yielding Varieties of Rice in South Asia*.

any “irrationality” on the part of the producers or “the possibility of increasing the output of old wheat by increased fertilization”.<sup>93</sup>

**Progressive farmers, limitations of state action and the fallacy of scale neutrality**

For the politicians such as the agriculture minister C. Subramaniam the new varieties served as cover for the larger changes he was bringing about in India’s economy. These were the introduction of remunerative prices to incentivize higher production, investment in fertilizer, agricultural subsidies (for fertilizers and tubewells) and a concentration of agricultural investment in some regions and large farmers within those regions. These represented drastic shifts. Remunerative prices meant an abandonment of the policy of securing cheap food for an industrial workforce and a shift of resources from industry to agriculture. It was also an acknowledgment that the Indian peasant would respond to market incentives, a discomfiting idea not just for Indian socialists but also for many of the best western economists. Massive import of fertilizer would have foreign exchange implications for industry and increased domestic production of fertilizer would divert resources from industries such as steel, which were to form the industrial base. A concentration of inputs was unacceptable to Gandhians, Nehruvians and socialists alike. Francine Frankel suggests that the claim of having found a “scientific formula; a calculated plan for increased production” strengthened Subramaniam’s hand in the food debate.<sup>94</sup>

The advantages of solving the lodging problem (if indeed it existed) and concentrating resources however inefficiently amongst farmers in a small region went beyond the rhetorical. This was so as the New Agricultural Strategy was a gigantic logistical exercise. Even during the IADP days when inputs were available to a mere seven of the best endowed districts, cooperatives lacked staff and suitable buildings for storing fertilizer; it was impossible to make available fertilizer “within bullock-cart distance of each farmer”.<sup>95</sup> Roads were unpassable during monsoon and improvements to the credit system were slow. New agricultural staff had to be recruited and the entire district administration had to be reoriented towards agricultural production. As an official study of the IADP experience pointed out, the availability of modern technology had necessitated “drastic

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<sup>93</sup> Surjit S. Sidhu, *Economics of Technical Change in Wheat Production in Punjab (India)* (Minneapolis, Mn, 1973).

<sup>94</sup> Frankel, *India’s Political Economy*, p. 251.

<sup>95</sup> Malone and Johnson, "The Intensive Agricultural Development Program ", p. 32.

administrative changes” in the IADP districts which would be hard to actuate in other areas.<sup>96</sup> Indeed, complaints about the availability of seed and fertilizer would last well into the 1970s. The same issues applied at the output end; indeed the imagery of a 1968 harvest so huge that it had to be stored in schools, cinema halls and government buildings has contributed significantly to Green-Revolution mythology.<sup>97</sup> The government had committed to buying produce at a minimum support price through the newly set up Food Corporation of India; this too was a gigantic logistical challenge. The government had a monopoly in the interstate movement of food grains, it would to purchase from farmers and supply to the Public Distribution System in other states. Rice being India’s most important crop, the FCI’s first district office was set up in Thanjavur, the rice bowl of Tamil Nadu. The bulk of its procurement operations moved to Punjab as wheat became an increasingly important crop. Punjab soon became the largest contributor of not just wheat, but also rice to the central foodgrain pool, thereby greatly enabling easy operation of the national food system.<sup>98</sup>

Similar considerations operated in justifying concentration of resources on larger farms within the region. For example, extension services were limited. Thus for all the professed faith in the universal rationality of the peasant, it was acknowledged that there was a breed of “progressive farmers” who were more amenable to technology change. The Bell Mission had noted David Hopper’s conjecture that farmers with 20-25 acres of land were most responsive to extension efforts and thus recommended that they be especially targeted.<sup>99</sup> Progressiveness of farmers of this size class perhaps had to do with their larger risk taking capacity and easier access to resources such as credit. While officially, state and public resources were available to all who requested it, the results of such an underlying bias were clear very quickly.

The package of technologies which constituted the Green Revolution (seeds, fertilizers and assured water supply) was ostensibly “scale neutral” and this was often emphasized by enthusiasts. While this claim overlooked the active policy of irrigation-expansion through encouragement of private tubewells (an indivisible input linked to a minimum viable farm size), the limits to scale neutrality went beyond tubewells alone. By the early

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<sup>96</sup> Malone and Johnson, "The Intensive Agricultural Development Program ", pp. 33.

<sup>97</sup> See for example Cullather, *The Hungry World*.

<sup>98</sup> On procurement, see George, *Some Aspects*.

<sup>99</sup> Bell, *Volume 2*, p. 42.

1970s, even Sivaraman had to acknowledge that it was a fallacy to assume that “scientific agriculture is neutral to scale”.<sup>100</sup> He argued that while marginal farmers had not benefited at all, both scientific evidence and statistical field study had shown that as long as marginal farmers could get inputs on time, they made the same productivity gains as large farmers. Credit was a bottleneck; while official criteria for loans had been changed from credit worthiness of the borrower to credit worthiness of the scheme in question, there were few noticeable results. Administrators felt that in universal schemes of credit, fertilizers and extension, rural social structures enabled large farmers to pre-empt services; yet, the Small Farmer Development Agencies founded to exclusively serve the poor had also shown disappointing results. Sivaraman blamed continuing problems with credit and unequal access to communal services such as irrigation and drainage; the powerful were able to take unfair share of water and disrupt the drainage of small fields by encroaching on drainage structures.<sup>101</sup> Thus a production programme based on spectacular yields of a few may be seen as an acknowledgment of the inability of the state to take on the interests of the rural rich and ensure equitable resource use to benefit all.

### **The Irrational Peasant?**

Faith in peasant rationality had a curious career during the “Green Revolution”. Perhaps the greatest irony was that the large land owning *Thakurs* of eastern India, on whom Schultz’s theory was based seemingly never responded to new incentives to change their methods or increase production. On the contrary, any increase in production was confined to the (relatively more) egalitarian society of Punjab. There was no evidence that all farmers responded similarly to incentives and even the seeming success of the Green Revolution would be accompanied by the resurgence of a narrative about a special creature called a “progressive farmer” and his cultural roots in Punjabi history.<sup>102</sup>

Of the “culturalists” criticized by Schultz, perhaps only one was mentioned by name; Kusum Nair whose influential book on the human element in India’s development had come out three years before his own.<sup>103</sup> In the late 1970s, when development planners

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<sup>100</sup> B. Sivaraman, “Scientific Agriculture is Neutral to Scale: The Fallacy and the Remedy”, *Journal of the Indian Society of Agricultural Statistics* (1973) 25: 75. This paper was initially delivered as the Rajendra Prasad Memorial Lecture at Kalyani University on 27<sup>th</sup> December 1972.

<sup>101</sup> B. Sivaraman, “Scientific Agriculture”, pp. 75-90.

<sup>102</sup> See for example Subramaniam, *New strategy*, p. 83.

<sup>103</sup> Nair, *Blossoms*.

had seemingly lost no faith in the absolute rationality of the peasant, despite it being overwhelmingly clear that the Green Revolution was confined to an increase in wheat production in northwestern India, Kusum Nair wrote two books attacking Schultz's doctrine, titled *In Defense of the Irrational Peasant* and *Transforming Traditionally*.<sup>104</sup>

The first book was a study of the massive contrast in wheat cultivation in Punjab and Bihar. Conventionally, this difference had been attributed to the fact that most of Bihar's farmers were poor. But as Nair showed, that while 80% of the farmers were poor, the remaining 20% owned 80% of all rural assets. Indeed the top 6% of farmers cultivated more land than all of Punjab, and it was these farmers that Nair studied. She argued that their low productivity was not due to resource constraints but because of a choice they had made to be "grossly inefficient".<sup>105</sup> Nair recommended that rather than getting caught up in a discourse on rational and irrational farmers, policy makers should recognize that there were simply good farmers and bad farmers. In other sectors such as industry, only the efficient and the meritorious could survive, and the government must adopt a policy of forcing a similar exit of bad farmers off the land. Instead of assuming that the farmer was driven by profit and incentivizing production through high prices (which also benefited the inefficient), a better policy was to impose a high tax on agriculture which would make it impossible to survive without high productivity.<sup>106</sup>

By the late 1970s, the failure of "modern inputs" to make a dent in the problem of increasing poor world food supplies, together with the rising cost of crucial inputs such as fertilizer led to a quiet acknowledgment that production increases from traditional methods had not reached their fullest potential. The 1978 World Development Report mentioned that a 30% yield increase on dry land and a 50 % increase in irrigated land could come solely from efficient use of existing inputs and infrastructure.<sup>107</sup> In that context, Nair went into the question of fertilizer and made the crucial point that in much of Asia, chemical fertilizer never replaced organic fertilizer; in Japan, farmers continued to use massive cartloads of manure together with cheaply available chemical fertilizer, while in the Philippines, chemical fertilizer was perhaps the first attempt to restore soil fertility in any way. The global disparities in chemical fertilizer use followed precisely

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<sup>104</sup> Nair, *In defense* and Nair, *Transforming Traditionally*.

<sup>105</sup> Nair, *In defense*, p. 17.

<sup>106</sup> Nair, *In defense*, p. 232.

<sup>107</sup> Nair, *Transforming Traditionally*, p. 49.

the same trend as the disparities in manure use. Indian policy had always been to encourage the use of manures which the farmer never took up unlike the farmers of China or Japan; the number of days spent by the Chinese farmer in preparing manure was an order of magnitude higher than those spent by his Indian counterpart. By the 1970s, Indian policy makers were engaged in an attempt to remove this constraint with a scheme to collect and supply farmyard manure which millions of farmers in many other countries usually produced themselves at no cost except their own labour.<sup>108</sup>

### **Conclusion**

Policy change of the mid-1960s was driven by the ideas of Indians, western advisers connected with the World Bank and diplomatic pressures exerted by the Johnson administration. Besides the larger shift in national resources from industry to agriculture, this change had at its heart a faith in peasant rationality, rooted in Theodore Schultz's theory of the "poor but rational" peasant. This theory implied that the peasant would respond to higher prices by producing and that the increased production could only come from new inputs rooted in research and technology.

Together with American pressure and an infallible faith in the product of high science, the idea of a peasant hungry for profit played an important role in the selection of inefficient seed varieties to orchestrate India's wheat revolution. In the next chapter, I shall explore how this idea, together with contingency and expediency shaped the tubewell revolution in the 1960s which was the wellspring of the remarkable growth in wheat yields.

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<sup>108</sup> Kusum Nair, *Transforming Traditionally*, p. 61.

## Chapter 6: Private Pumps and the Green Revolution

The period from the mid-1960s saw a boom in the extension most fundamental technical input in Indian agriculture which provided the basis for fertilizer use, namely irrigation. There was a largely hidden transformation in the quantity and nature of the water supply to Indian farmers, and at the heart of this transformation was a relatively new technology namely the privately-owned tubewell. In this chapter, I shall tell the story of how private tubewells became central to India's Green Revolution.

The question of water supply was central to India's New Agricultural Strategy, and a very particular policy was followed: the promotion of privately-owned groundwater irrigation facilities was the central feature. World Bank experts felt that irrigation was a key input to productive agriculture in India, but saw India's emphasis on large-scale canal irrigation systems and public tubewells as misplaced in that they were designed to protect the maximum possible number of farmers from drought by spreading water thinly over vast areas. These systems were seen as unable to provide for the new objectives of intensive water application and timely availability of water which was seen as the key to high-yielding agriculture. The profit-maximization objective of the individual cultivator which was placed at the centre the drive for higher production was seen to be in conflict with the equity objectives of public irrigation facilities. Hence the World Bank pressed for a new irrigation policy, focussed on *private* tubewells. Influential Indian bureaucrats were also in favour of promoting private tubewells, though their reasons had as much to do with the paucity of public finance for irrigation, as well as an unprecedented drought in the mid-1960s (which required the quick results that tubewells rather than surface irrigation could provide), as with any inherent operational advantages of private tubewells.

The active state policy of promoting private initiative in agriculture and remunerative grain prices provided a spur to private tubewells, for irrigation not only made for higher yields in its own right but also provided an incentive to fertilizer use by mitigating risk. The application of the latest methods to optimize irrigation schedules for the new seeds in the late 1960s also suggested that private tubewells were better suited to the water needs of modern agriculture than canals. I will however show that this marginal superiority played a negligible role in increased yields compared to the massive leap from rainfed cultivation to having irrigation of any sort; further, well-managed canal systems

acquitted themselves in an excellent fashion. I will argue that the correlation between ownership of a tubewell and adoption of fertilizers, which was one reason for state promotion of tubewells did not suggest causation; the correlation could easily be explained by the larger resources of tubewell owning farmers and their higher capacity to bear the risk of new technology.

I

The few works which have noted the importance of irrigation during the Green Revolution are not those of historians but activists and social scientists- for example, Vandana Shiva has devoted a chapter on large dams and their socio-ecological impact in her study of the Green Revolution, reflecting a common association of irrigation with dams in the literature.<sup>1</sup> In her early field study of the Green Revolution, political scientist Francine Frankel has identified the importance of groundwater irrigation to the new agricultural strategy and the availability of credit for tubewell investments as a bottleneck to the adoption of the new seeds by small farmers, contributing to rural inequity.<sup>2</sup> In other work, she has also mentioned in passing the important role played by the advice of World Bank experts in the adoption of the private-tubewell strategy.<sup>3</sup> Later works by economists focused on groundwater irrigation have noted the importance of precisely-timed irrigation and have identified the need for an end user controlled water source as an important driver of farmer investment in groundwater irrigation.<sup>4</sup>

### **The Bell Mission and Indian Irrigation: Privatization and Intensification**

Through the 1950s, while there was some provincial government support for private groundwater-irrigation efforts, the overwhelming emphasis was on public systems. This changed in the 1960s with the Third Plan (1961-66) committing increased funds to minor

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<sup>1</sup> Vandana Shiva, *The Violence of the Green Revolution: Third World Agriculture, Ecology and Politics* (London, 1991), pp. 82-121.

<sup>2</sup> Francine Frankel, *India's Green Revolution: Economic Gains and Political Costs* (Princeton, NJ, 1971).

<sup>3</sup> Francine Frankel, *India's Political Economy: The Gradual Revolution* (Princeton, 1978), p. 243.

<sup>4</sup> See for example B.D. Dhawan, *Development of Tubewell Irrigation in India* (New Delhi, 1982) and Tushaar Shah, *Taming the Anarchy: Groundwater Governance in South Asia* (Washington, DC, 2009).



irrigation and rural electrification. In the mid-1960s, two factors intensified this emphasis on private tubewells. The first was the advice of the World Bank's Bell Mission.

Throughout the 1960s, observations in the Bank's annual reports on the economic prospects of India touched upon irrigation issues; early on it recommended a reorientation of the Community Development programme towards production, emphasizing the importance of minor irrigation.<sup>5</sup> The 1964 volume reflected the growing frustration in India's policy circles with the inefficiency of large-scale irrigation projects. It felt that insufficient attention had been paid to the economic criteria for the selection of irrigation projects, resulting in the misdirection of foreign exchange. Too much capital and talent was locked up in the long gestation periods of these projects. It also lamented the lack of coordination between the irrigation departments in charge of supplying water and the agriculture departments which were to ensure its optimal use. Finally, the bank criticized the general tendency to spread water too thinly over the maximum possible area without regard for the ability of farmers to use the water.<sup>6</sup>

This critique was further articulated by the World Bank's Bell mission that studied India's economic development efforts during the same year. Various chapters and sections in this long report were authored by different economists with both the general introduction and the chapter on irrigation emphasizing the fact that it could not be fully regarded as a team effort.<sup>7</sup> There were at least three distinct threads of thought about irrigation in the report which I shall summarize here.

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<sup>5</sup>World Bank, *India - Current economic position and prospects*. Asia series; no. AS 83 (Washington, DC, 1961), p. 23. Accessed online at <http://documents.worldbank.org/curated/en/1961/03/724479/india-current-economic-position-prospects> on 23rd February 2015.

<sup>6</sup>World Bank, *India - Current economic position and prospects*. Asia series; no. AS 105 (Washington, DC, 1964), pp. 19-20. Accessed online at <http://documents.worldbank.org/curated/en/1961/03/724479/india-current-economic-position-prospects> on 23rd February 2015.

<sup>7</sup> Bernard R. Bell, *Report to the President of the International Bank for Reconstruction and Development and the International Development Association on India's Economic Development Effort, Volume I, Main Report* (Washington, DC, 1965), p.ii. Accessed online at <http://documents.worldbank.org/curated/en/1965/10/12648064/report-president-international-bank-reconstruction-development-international-development-association-indias-economic-development-effort-vol-1-14-main-report> on 23rd February 2015.

Prior to the Bell mission, a joint FAO/IBRD mission headed by M.L. Garnier had reviewed India's irrigation experience and his report was appended to the report of the Bell Mission of which he was also a member. This report was clearly aimed at dispelling the cynicism about irrigation that gripped many Indian and western observers by the early 1960s. While previous observers had criticized the long gestation period of large schemes, Garnier emphasized that in all countries, the "revolution" from dry to irrigated farming took 20-30 years no matter how well the scheme was planned,<sup>8</sup> and he asserted that few other spheres offered an opportunity equivalent to irrigation in providing lasting results for improving agriculture. Even though India had three times as much irrigated area as the United States did and accounted for a fifth of the total area under irrigation in the world, the oft-criticized large outlay on irrigation in the five year plans was, according to Garnier, too low considering India's monsoonal climate, which concentrated rains to a small portion of the year. His main conclusion was that India had "reached a cross roads in irrigation" and he argued for a further acceleration of irrigation efforts, albeit with a change in policy.<sup>9</sup> According to Garnier, the main problem was that the extension of irrigation had an insufficient impact on agricultural production in India and he made the case for perennial, intensive irrigation whether it be from large or from small systems. According to him there had been a tendency, both in the case of major projects and state tubewells to spread the benefits too thin with protection from drought, rather than intensification of cropping or the promotion of high value crops in mind. According to Garnier, the cropping intensity in India was too low and it was in addressing this problem that irrigation schemes must be directed; a concentration of irrigation benefits on smaller tracts of land would enable diversification and intensive cropping. The inability of large-scale systems to keep to a schedule of water delivery meant that farmers had to spend much human and animal labour to get a low discharge from private wells, which had the

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<sup>8</sup> Louis Garnier, "Typical Features of Irrigation Development in India" in Bernard R. Bell, *Report to the President of the International Bank for Reconstruction and Development and the International Development Association on India's Economic Development Effort, Volume 4, Agricultural policy: appendices VI - X* (Washington, DC, 1965), pp. VI-12. Accessed online at <http://documents.worldbank.org/curated/en/1965/10/12648079/report-president-international-bank-reconstruction-development-international-development-association-indias-economic-development-effort-vol-4-14-agricultural-policy-appendices-vi-x> on 23rd February 2015.

<sup>9</sup> Garnier, "Typical Features", pp. VI-1.

advantage of being perennial. The way forward then, were intensive rather than extensive irrigation works, with the benefits concentrated over a lesser area where plentiful water would be available at will throughout the year. Tubewells could also provide water perennially at will though he cautioned against investment in them until sufficient groundwater surveys had been conducted.<sup>10</sup>

Strictly speaking, Garnier was wrong to characterize drought protection for the many as Indian irrigation's main aim. From the colonial era, irrigation schemes were classified as (drought) protective or productive, and the latter had accounted for an overwhelming share of the irrigation expenditure. Intensification of agriculture had also long been an aim for irrigation in independent India. However, the method of selecting irrigation projects, whose essential metric was capital cost per acre had persisted, despite much conversation about alternatives. It was this metric, rather than flawed policy that had partly resulted in the thin spread of water, as the irrigation bureaucracy preferred to inflate the acreage benefiting from a project to reduce the per-acre cost.

The chapter on irrigation in the Bell Mission's report drew in large part from Garnier's report but emphasized that they were not in complete support of his views, noting that while nobody would disagree over the importance of water in Indian agriculture, in no other aspect of agricultural policy this important was there "so little that is conclusive in the way of water research or economic appraisal".<sup>11</sup> It pointed out that both experiments and field studies had demonstrated the critical importance of irrigation in enabling the full impact of fertilizer use; in fact, the chapter on fertilizers had a section titled "the importance of irrigation in relation to fertilizer use".<sup>12</sup> Elsewhere in the Bell Report, the production functions used by the government planners were systematically critiqued by David Hopper who argued that enough work had not been done to establish the joint production function of water and fertilizer, leading to an understatement of the importance

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<sup>10</sup> Garnier, "Typical Features", pp. VI-1 – VI-33.

<sup>11</sup> Bell, *Volume 2, Agricultural Policy* (Washington, DC, 1965), p. 70. Sir John Crawford (National University of Australia), Wolf Ladejinsky (Land Reform Specialist, United States), M.L Garnier (FAO, Rome), Louis Goreux (FAO, Rome) and W.D. Hopper (Ford Foundation, New Delhi) contributed to the Bell Mission's volume on agricultural issues.

<sup>12</sup> Bell, *Volume 2*, pp. 64-65.

of irrigation.<sup>13</sup> While Garnier had largely skirted the question of a preference for either canals or tubewells, the main report had a distinct bias in favor of groundwater development. Commenting on Garnier's conclusion that agricultural intensification and diversification should be the objectives of irrigation, the authors agreed that the ability to command water when and in the volume he desired was important to the cultivator. To them, this pointed to the importance of small private tubewells which could enable double or even triple cropping and were cheaper than large systems. The main report conceded that when water availability was limited, the question of best use (extensive or intensive) was open, but on the whole they leaned to the view "that in many areas it will be found that best results will come from encouraging private investment and management."<sup>14</sup> While they agreed that rigorous studies of environmental and economic impact must take place before investment in surface irrigation, they disagreed with the same view in the case of minor irrigation; the short term exigencies of Indian agricultural policy justified the risk of infructuous investment in groundwater as long as surveys took place concurrently with development and a close watch was kept on tell-tale signs of depletion.<sup>15</sup>

Perhaps the most interesting and direct approach to the tubewell vs. canals problem was an appendix on the factors of production in Indian agriculture by W.D. Hopper, the economist with the Ford Foundation in New Delhi, who had perhaps the closest connection to India of the various authors of the report.<sup>16</sup> The primary but unstated innovation in Hopper's analysis was the application of marginalism to water as an input in agriculture. Indian planners saw irrigation as a binary characterized by its presence or absence, with no regard to the quantity of water applied. A strict mathematical analysis of the role of irrigation in agriculture was hard; in previous work, Hopper himself had

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<sup>13</sup> W. David Hopper, "Production Coefficients: The "Yardsticks" for Planning" in Bell, *Volume 3*, pp. IV-1 – IV-13.

<sup>14</sup> Bell, *Volume 2*, pp. 74.

<sup>15</sup> Bell, *Volume 2*, pp. 74-75.

<sup>16</sup> Hopper acknowledged that he had drawn liberally and without citation from the work of volume co-author Dr. L. Goreux of the FAO whose insights and thinking had shaped his own to the point where assignment of ideas was impossible. W. David Hopper, "The Factors of Production to Generate an Expanding Agriculture" in Bell, *Volume 3*, pp. VI-1 – VI-47.

admitted that the (extremely hard) inclusion of rainfall into the analysis was crucial in scrutinizing the value of irrigation. In the same work, he had found that while the number of irrigations applied was somewhat important, the total quantity of water applied was a statistically insignificant variable in the prediction of yields;<sup>17</sup> this would imply that the quantity of water was not amenable to marginalist theory. Nevertheless, he applied marginalism to water in his crucial policy advice.

According to Hopper, the problem was that irrigation planners did not visualize water as an input to agriculture. This was reflected in the fact that irrigation potential was measured in additional irrigated acres, rather than in the quantity of water supplied, crucially neglecting the water needs of various crops.<sup>18</sup> While the actual water needs of crops was an unsettled matter, Hopper's assertion was something of a sweeping mischaracterization. The policy in most states presumed a cropping pattern and (based on what was known about water needs) calculated the acreage it was possible to irrigate in a project. While implementation was poor, some states even had a policy called *localization* whereby the cropping pattern was specified by regulation; this was to restrict the cultivation of water intensive crops such as rice and sugarcane. Perhaps what Hopper really meant was that the supply of water did not fully enable choice of cropping pattern by the cultivator.

According to Hopper, be it tubewell or canal, the crux of the irrigation problem was the differing view of the object of system design between the engineer and the agriculturist. Engineers saw total water as the fixed quantity and tended to optimize agricultural output per unit volume of water than per unit of land. If there were initially increasing and then diminishing marginal returns to water application per acre beyond a point, more total agricultural production could be obtained by serving additional acres after supplying the optimum amount. However, the yield as a function of water application was usually an "inverted dish" parabola with constants such that marginal returns would diminish from the application of the very first unit of water. Given a fixed quantity of water, the bureaucracy's traditional strategy of maximizing area served was the best solution from

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<sup>17</sup> W. David Hopper, "The Economics of Fertilizer Use—A Case Study in Production Economics", *Indian Journal of Agricultural Economics* (1962) 17: 12-22.

<sup>18</sup> Hopper acknowledged that he had drawn liberally and without citation from the work of volume co-author Dr. L. Goreux of the FAO whose insights and thinking had shaped his own to the point where assignment of ideas was impossible. Hopper, "The Factors", pp. VI-1 – VI-47.

not just a social and political point of view, but even from the economic point of view of maximizing agricultural production; there were of course limits to this strategy as water losses increased with the area served.<sup>19</sup>

This model of utility-maximization where total water was a fixed quantity and acreage was to be maximized conflicted with the profit-maximization model of the enterprising cultivator; for him land (rather than water) was the fixed quantity and water was a variable to be varied. As the marginal cost of additional water was lower than marginal returns in the case of public tubewells (and zero in the case of canals where there was a flat per acre charge), it made sense for the cultivator to apply as much water as possible even as marginal returns diminished. Hence there was conflict between the system and the individual. In the case of public systems be it tubewells or canals, water application was limited by rationing. But there was a tendency to supplant this regulatory rationing with a “price-based system”; gains could be made by “perceptive cultivators” tempting the “human frailties” of canal supervisors and tubewell operators with bribes to supply more than their allotted quota. This, according to Hopper was the reason that public tubewells, despite being designed for 400 acres, public tubewells were irrigating barely 150 acres on an average and often less than 100 acres due to “legal, illegal or accidental” means. Private tubewells of the same capacity irrigated only 60-120 acres.<sup>20</sup>

Hopper’s model of a conflict between the yield-maximization strategy of the cultivator and the social objectives of the irrigation planner was apparently shared by Indian irrigation engineers. Their collective recommendation was to continue on a policy favouring extensive rather than intensive irrigation, with groundwater being to supplement supplies to promote intensification; they did not however go in the question of ownership of tubewells.<sup>21</sup> As irrigation engineers controlled only large public schemes, it was natural that they would argue in favour of the same. Nevertheless, Hopper’s analysis did not show that public tubewells were inherently unsuitable for intensive agriculture, only that their designed command area was too large to do so. Just as he had

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<sup>19</sup> Hopper, “The Factors”, pp. VI-40 – VI-42.

<sup>20</sup> Hopper, “The Factors”, p. VI-42.

<sup>21</sup> Central Board of Irrigation and Power, *Recommendation of the Ninth Irrigation and Power Seminar* (New Delhi, 1964), p. 21.

found that corruption and favouritism could reduce their command area, this could also be done by design, as UP had been attempting to do.<sup>22</sup> It is notable that he used the public tubewells amenability to corruption to serve the needs of the few as an argument for giving up the equity objective altogether with a policy favouring private tubewells.

According to Hopper, while engineers saw water as supplemental to rainfall in the case of drought and sought to maximize the area served, agriculturists saw this policy as inconsistent with the object of yield-maximization by the application of non-water inputs.<sup>23</sup> While politics meant that a contraction in canal-irrigated area was not possible, according to Hopper, the operation of private tubewells had demonstrated the possibilities of intensive irrigation. Evidence from Punjab, Bihar, Madras, UP and Rajasthan where farmers controlled their own water supply pointed to intensive land use with the raising of three or even four crops a year. This assured, perennial water,

Seems to be the key that opens up the way to a multitude of opportunities increase annual product per acre...by an intensive agriculture that involves the use of complementary inputs like fertilizer and plant protection measures in a cropping pattern significantly altered from that followed before the acquisition of the new facility.<sup>24</sup>

According to Hopper, “accumulating evidence, much of it unpublished” showed that private tubewells made for intensive farming; this was in sharp contrast to data which showed that cropping intensity in canal commands was actually *less* than in areas without irrigation.<sup>25</sup> The latter was an entirely erroneous impression that had to do with the way irrigation and land use statistics are presented in India. The published data gives the gross cropped area (which includes area cropped more than once) and the net cropped area; the ratio of the two yields the cropping intensity for India as a whole. Also presented are the gross irrigated area (which includes the area irrigated more than once) and the net irrigated area; the ratio of these yields the *irrigation intensity*, rather than the cropping intensity and the former was possibly confused to be the latter by Hopper. Irrigation was

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<sup>22</sup> Committee on Plan Projects, *Report on State Tube-wells (Uttar Pradesh)* (New Delhi, 1961), p. 112.

<sup>23</sup> Hopper, “The Factors”, p. VI-43.

<sup>24</sup> Hopper, “The Factors”, p. VI-45.

<sup>25</sup> Hopper, “The Factors”, p. VI-45.

often applied only to an extra dry season crop (which could not have been raised without it) with the monsoon crop grown under unirrigated rainfed conditions; thus increasing the cropping intensity but not the irrigation intensity. A decade after Hopper, the economist VKRV Rao would make the same mistake in a public lecture, prompting a seminar on the role of irrigation in Indian agriculture; it would be many years until the erroneous impression was decisively corrected.<sup>26</sup>

To explain this idea that land under public irrigation was cropped less intensely than dry land, Hopper turned to the farmer's psychology of risk. In the absence of canal irrigation cultivators grew multiple inferior crops every year while canal irrigation had resulted in the extension of sugarcane and wheat cultivation. Sugarcane and wheat were reasonably high value crops which needed irrigation but could withstand some drought in the case of supply problems; fields bearing these crops however could not have a second season. "Independence of government authority" whether canal supervisor or tubewell operator, with the concurrent reduction in risks associated with timing and volume of water would lead to a domination of high input, high return crops and multiple cropping. This was not borne out by existing data; as I will show, Punjab's private tubewell-irrigated districts in fact irrigated more wheat than its canal districts. To Hopper, it was clear that private tubewells were the way forward to intensify agriculture, even as he acknowledged that the almost complete lack of data on irrigation and its organization at the village level gave all discussions on irrigation a "wonderful dreamy quality, uncluttered by facts, dominated by vague opinions that are strongly held and deeply entrenched in custom and traditional rivalry",<sup>27</sup> referring perhaps to the rivalry between agricultural departments and irrigation departments.

To summarize, all three sets of opinions in the Bell report agreed on the need for intensification of water application and for the availability of water at the cultivator's will to promote multiple cropping, fertilizer use and yield-maximization. Garnier focused on

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<sup>26</sup> Dr. Rao, made the comments in a lecture on "New Challenges before Indian Agriculture" at the Panse Memorial Lecture of the Indian Society of Agricultural Economics in April 1974. This led to a seminar on the role of irrigation in India's agricultural development, see Indian Society of Agricultural Economics (ed.) *Seminar on Role of Irrigation in the Development of India's Agriculture* (Bombay, 1976). Panse's error has been noted in Dharm Narain and Shymal Roy, *Impact of irrigation and labor availability on multiple cropping: A case study of India* (Washington, DC, 1980), p. 11.

<sup>27</sup> Hopper, "The Factors", p. VI-47.



the reform in the design and execution of large-scale systems and was cautious about tubewells pending knowledge of groundwater availability. The authors of the chapter on irrigation leaned towards private tubewells as the solution. Hopper felt that spreading irrigation benefits as thinly as possible was actually the most optimum way to use scarce water to maximize production from public systems. This greater good however conflicted with the private yield-maximization strategy of the individual cultivator who was more likely to go in for multiple cropping and adopt modern inputs like fertilizers if he had access to an assured plentiful supply of water free of government control. Making the implicit assumption that the problem of equitable distribution did not exist in the case of groundwater as it did in the case of surface water, he effectively called for the privatization of the resource by the promotion of private tubewells to subvert the regulatory distribution which limited supplies in the case of public tubewells. Vesting control of volume and timing of irrigation to the profit-maximizing cultivator was seen as an enabler of high-input, high-output agriculture.

In passing, Francine Frankel has seen the advice of these experts as crucial in the decision to go in for private tubewells, which became a central technology of the Green Revolution.<sup>28</sup> While this is likely true, it must be emphasized that the World Bank advice was more about an agricultural problem than a food problem; their emphasis was on cash crops. The advice was about convincing India to shift its priorities from industry to agriculture, and less about a shift within agriculture from cash crops to food crops. Both Garnier and Hopper emphasized “high value crops”, and at least to Hopper, wheat, the most expensive of foodgrains in India was clearly not high value enough. Very soon, however, India’s problem would soon be seen as a food problem, and the most visible success of tubewells would be in raising wheat yields.

### **Drought, economic crisis and a private tubewell boom**

The submission of the Bell Mission’s report in 1965 coincided with the beginning of a severe crisis of food production in India. The years between 1965 and 1967 saw severe failure of the monsoon and consequent exceptional drought. Surface irrigation systems

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<sup>28</sup> Frankel, *India’s Political Economy*, p. 243.

were unable to help; official figures show that the area irrigated by both government canals and small tanks actually fell in absolute terms 1965-66.<sup>29</sup>

To mitigate the impact of the drought, governments and cultivators in India turned to privately-led groundwater development as had been the case during several droughts in British India. The crisis of public finances which precluded the commencement of new large surface irrigation schemes also intensified the focus on tubewell schemes. In a 1967 speech, Indira Gandhi argued that India needed to double its irrigated area and that the focus be on minor-irrigation schemes in view of the paucity of funds and the quick fruition they promised. Pointing out that the country had failed in utilizing its tremendous groundwater resources, particularly in the Gangetic plains, she argued that as irrigation was cheapest of all inputs, focus on it (rather than tractors or fertilizers) could enable a social levelling in the countryside.<sup>30</sup> Subsidies and loans were to be provided for constructing wells, tubewells and putting up pumps. The Congress Party manifesto of 1966 emphasized reliance on minor irrigation and rural electrification for lifting water from open wells and tubewells.<sup>31</sup> In 1965, the National Development Council had directed that the energization of pumpsets be made the focus of the rural-electrification programmes.<sup>32</sup> While this had always been the case in practice, the decision was important in shifting even the rhetoric away from rural industry. A target of electrifying 100,000 villages in time for the Gandhi birth centenary of 1969 had also been set.<sup>33</sup>

These initiatives intensified the emphasis on rural electrification and minor irrigation that had begun during the Third Plan and the 1960s (particularly the latter half) was a time of great investment and achievement in India's groundwater sector. During the Third Plan (1961-66), for the first time, the actual expenditure on rural electrification, at Rs. 1.53 billion exceeded the already high allocation of Rs. 1.05 billion. This was to be dwarfed by spending during the Plan Holiday (1966-69) when Rs. 2.38 billion was spent on rural

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<sup>29</sup> Ministry of Agriculture, *Indian Agricultural Statistics* (New Delhi, 1970).

<sup>30</sup> Times of India New Service, "Increase Irrigated Area: PM", Times of India dated May 13<sup>th</sup> 1967.

<sup>31</sup> Subramaniam, *Hand of Destiny*, p. 229.

<sup>32</sup> Times of India New Service, "High Priority for Rural Electrification: NDC Committee's Suggestions for 4<sup>th</sup> Plan", *Times of India* dated 4<sup>th</sup> January 1965.

<sup>33</sup> Central Board of Irrigation and Power, *Recommendation*, p. 14.

electrification; a sum marginally higher than the total expenditure on the same in the fifteen preceding years. The minor-irrigation head also saw similarly high levels of public investment.<sup>34</sup> Together with the private efforts of individual cultivators, often financed by government backed loans, this inaugurated the period when the growth in Indian irrigation was led by groundwater extraction and there was a considerable growth in the number of tubewells and pumps in the 1960s as the National Commission on Agriculture estimated in its report published in 1976. (See Table 6.1).

Item	Pre-plan, 1951 (‘000)	End of First Plan, 1956 (‘000)	End of Second Plan, 1961 (‘000)	End of Third Plan, 1966 (‘000)	End of Plan Holiday, 1969 (‘000)
<b>Wells in use</b>	N.A.	3624.0	4474.0	5111.0	5908.0
Annual growth rate			4.3	2.7	4.9
<b>Diesel pumps</b>	66	123.0	230.0	465.0	721.0
Annual growth rate		13.3	13.3	15.1	15.7
<b>Electric pumps</b>	21	56.0	199.0	513.0	1089.0
Annual growth rate		21.7	28.9	20.9	28.5
<b>Private tubewells including filter points</b>	21	30.0	49.0	113.0	246.0
Annual growth rate		7.4	10.3	18.2	29.6
<b>State tubewells</b>	3	7.0	10.0	13.0	15.0
Annual growth rate		18.5	7.4	5.4	4.9

**Table 6.1: Groundwater irrigation structures in India, 1951-1969.**

**Sources and Notes:** National Commission on Agriculture, *Report of the National Commission on Agriculture, Part V: Resource Development* (New Delhi, 1976), p. 31. The figure mentioned for private tubewells in the pre plan period, being equal to the electric pumps likely includes pumps on open wells. There was little private- tubewell development in the pre-plan period. It is probable that the figures for electric and diesel pumps include figures for the respective type of private tubewell.

### Matching Irrigation to crops and climates

In colonial India, irrigation projects were classified as productive or protective; the former could be expected to produce revenue for the state while the latter was expected to be run at a loss to prevent famine. Compared to productive works, there were few protective works and many of these turned out to be productive, in part due to conservative British

<sup>34</sup> Rs. 2.7 billion was spent on minor irrigation during the Third Plan (1961-66), almost half the Rs. 5.83 billion spent on large schemes. During the 1966-69 triennium, about Rs. 3.14 billion was spent by the government on minor irrigation, compared to Rs. 4.27 billion on major and medium projects; this was the closest that spending on minor irrigation had come to the spending on major projects. See National Commission on Agriculture, *Report of the National Commission of Agriculture, Part V: Resource Development* (New Delhi, 1976), p. 30.

policies. Most irrigation works built in independent India were also designed to be productive. But in the 1960s, an idea was born that somehow all the irrigation works built in India were protective rather than productive and this had to do with evolving ideas of the water needs of various crops in diverse climates.

The quantity and scheduling of irrigation had been determined by the colonial irrigation bureaucracy by varying the depth and intervals of irrigation and picking combination that gave the best yield with a reasonable total water use. The extent to which these results were used to plan irrigation, if at all, is not known, but it is likely that due to the very small number of trials, the optimum combination had not been struck even in research fields; the state of the art in the case of wheat as late as the 1960s came from a couple of trials at Lyallpur in the early 1930s. This depth-interval-yield approach continued to constitute the bulk of the research on irrigation in India until the mid-1960s, even as ideas about irrigation science were changing as the result of agricultural scientists taking an increasing interest in the problem. From 1956, scientists at the Indian Agricultural Research Institute began to compute the soil moisture deficit in the root zone of the crop and varying irrigation in accordance with the same. But to cover the entire range of soil types and weather conditions present in India was impossible, particularly as expensive equipment such as tensiometers and resistance meters were needed; soil sampling too was an expensive affair. Another technique new to India was the climatological approach; its central idea was that it was meteorological factors, rather than the plant or the soil which was the fundamental determinant of water consumption. As isocline maps were easy to plot with a relatively small number of cheap evaporimeter readings, the technique had “high extension value”. But given limited water supply, this still left the open question of the optimal timing of water application.<sup>35</sup>

Under the moisture deficit approach, the critical period when water application was absolutely necessary was taken to be the period when the most water was consumed. But as per the new climatological approach, this was merely the time when it was hot; naturally, there was evaporation. The critical period thus had to be determined by the tolerance of the plant to moisture stress at various periods, by studying the effect on yield of withdrawing irrigation at various stages of plant growth.<sup>36</sup> Such experiments, together

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<sup>35</sup> N. G. Dastane, Mahendra Singh and V. K. Vamadevan, *Review of Work done on Water Requirements of Crops in India* (Poona, 1970).

<sup>36</sup> Dastane *et. al*, *Water Requirements of Crops in India*, p. 56.

with other agronomic studies were conducted on the dwarf wheats as part of the Coordinated All India Wheat Improvement programme by the American soil scientist BC Wright and others in the late 1960s. They found that yields were dependent on the timing of irrigation and the periods when water was critical were determined.<sup>37</sup> The tall varieties had never been optimized for yield in such a fashion; this led to the idea that the HYVs required “more precise and scientific water management”<sup>38</sup> than local varieties. That the performance of tall varieties could be improved through “scientific water management”<sup>39</sup> was not even considered. Making a plea for productive (or rather, more suited to the HYV), rather than protective irrigation to a general audience, J.S. Kanwar, the first Deputy Director General for Soil Agronomy, Water, and Engineering of the Indian Council of Agricultural Research produced a five stage schema for increasing yields. The first was the addition of irrigation, next was HYV followed by fertilizer, then came better water management followed finally by pest control. That better water management could follow irrigation before HYVs and fertilizers were introduced was not considered. It was perhaps assumed that the best practices with tall varieties had already been adopted and there was no need for research; as Dr. Swaminathan said in a different context, there was no need for control studies with local tall varieties as his control was the “entire lived memory” of the Indian peasant.<sup>40</sup>

### **The Rise of the Tubewell**

Much of the increased wheat irrigation came from tubewells, though as I showed in Chapter 1, the extent of domination by tubewells was far from total. Wheat had never been thought of as a crop that would benefit peculiarly from tubewells; indeed while plans for the pioneering UP tubewell scheme assumed a cropping pattern identical to that of the Upper Ganges Canal, if any crop was expected to be disproportionately grown, it was water-intensive sugarcane rather than wheat.<sup>41</sup> In early years, public tubewell irrigation was preferentially used for sugarcane cultivation in western UP, with the crop accounting

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<sup>37</sup> Gill, *Research*, p. 132.

<sup>38</sup> J S Kanwar, "From Protective to Productive Irrigation", *Economic and Political Weekly* (1969) 4: A23

<sup>39</sup> Kanwar, "From Protective", A23

<sup>40</sup> Subramaniam, *New Strategy*, p. 89.

<sup>41</sup> William Stampe, *The Ganges Valley State Tube-well Irrigation Scheme: a system of state irrigation by Hydroelectric power from underground sources, 1934/35 to 1937/38* (Allahabad, 1936), pp 27-30

for 35% of the total tubewell-irrigated area during the programme's infancy in 1934-35 as compared to just 16% of the area irrigated by the Upper Ganges Canal. However, the proportion of tubewell-irrigated area devoted to sugarcane quickly reduced to just 13% in 1938-39 compared to 12% on the Upper Ganges Canal in the same year. If the tubewells preferentially irrigated a particular crop, it was wheat which accounted for nearly 57% of the tubewell-irrigated area in 1937-38 (compared to 24% on the Upper Ganges Canal in the same year) and 55% in 1938-39 (24% on the Upper Ganges Canal).<sup>42</sup>

In the late 1930s, this cropping choice may have simply been the result of the global fall in the prices of cash-crop commodities. Yet over the next 30 years in northwestern India, groundwater-irrigated tracts devoted a greater proportion of their areas to wheat than canal-irrigated tracts.<sup>43</sup> This may have been because the cost of irrigation from tubewells (public or private) to the cultivator was a function of the volume of water withdrawn, rather than the area irrigated (as in canal tracts). Irrigated wheat was a reasonably high value crop which did not require too much water, unlike a crop like sugarcane; the latter might have produced greater gross return but at a high cost. In other words, for wheat, the marginal return to water application was high.

After the mid-1960s, the availability of fertilizer (which was only used with irrigation) increased the differential in yields between irrigated and unirrigated wheat, and government support prices for wheat also increased, making wheat irrigation hugely profitable. Together with increasing support for tubewell irrigation through loans, subsidies and rural electrification, this not only propelled a tubewell boom but likely also made wheat the most profitable crops to be irrigated, even with canals. Punjab as a whole lost two fifths of its irrigated sugarcane acreage between 1966 and 1972; in comparison,

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<sup>42</sup> United Provinces Public Works Department, *Irrigation administration report of the United Provinces, 1938-39* (Allahabad, 1939).

<sup>43</sup> In the case of Punjab, this may be exemplified by a comparison of the districts of Jullundur and Ludhiana (where irrigation was mostly from wells) with Hissar (where irrigation was almost exclusively from canals) and Karnal (a mix of both, with canals dominating). In 1955-56, the well irrigating districts devoted a larger proportion of their irrigated land to wheat; this concentration which had intensified by 1965-66 with the growth of tubewells further increased in 1971-72 through the Green Revolution which was focussed on wheat. Compiled from Directorate of Economics and Statistics, *Indian Agricultural Statistics* (New Delhi, 1957-75).

the much lamented decline in the irrigation of pulses, an important source of protein in the Indian diet was barely 8%.<sup>44</sup>

To Kanwar, productive irrigation meant careful use of limited water supplies on HYVs; indeed he emphasized that spectacular production gains could be achieved without increasing water supply.<sup>45</sup> Thus making Indian irrigation productive had multiple meanings; as I showed, the World Bank experts whose recommendations preceded the adoption of HYVs saw the *intensive* application of large quantities of water as crucial. This was the change they recommended to transform India irrigation from protective to productive; this had led to substantial government support for private tubewells, which Kanwar was in agreement with. This notion that the rise of the private tubewell was due to the failure of canal systems to supply the precise and intensively timed water needs of modern agriculture and that tubewells were somehow inherently more suitable to HYV seeds is prevalent to the present day.<sup>46</sup>

It is true that groundwater irrigation had always been associated with somewhat higher yields; before the advent of the HYVs, this was usually attributed to careful cultivation and judicious and sparing (rather than excessive) use of hard won water.<sup>47</sup> But the role of the better *quality* of irrigation (whether that meant more water or more precisely timed water) from tubewells must not be overemphasized. To begin with, such was the sheer scale in the rapid expansion of irrigated acreages that the marginal improvement that came from precise timing were overwhelmed by the massive leap in productivity that came from the shift to irrigation of any sort from rainfed cultivation; at least in the medium term, *quantity* mattered more than quality. The superiority of tubewells in enabling precise timing is also questionable; production shortfalls in the 1970s were regularly explained not just by the failings of canal irrigation but also by the upsetting of tubewell-irrigation schedules by power cuts, diesel shortages (this was the era of energy crises) and pump breakdowns.<sup>48</sup> On well managed systems at least, canals held their own and were

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<sup>44</sup> Compiled from Directorate of Economics and Statistics, *Indian Agricultural Statistics* (New Delhi, 1968-75).

<sup>45</sup> Kanwar, "From Protective", pp. A21-A26

<sup>46</sup> See the burgeoning economic literature on tubewells, especially Shah, *Taming the anarchy*.

<sup>47</sup> See for example Ministry of Community Development, *Irrigation Water and the Community* (New Delhi, 1957), p. 6.

<sup>48</sup> See for example, Ministry of Finance, *Economic Survey of India* (New Delhi, 1975).

entirely consistent with high-yielding agriculture; this is demonstrated by the experience of Haryana, which was carved out of Punjab in 1966. Groundwater's share in Haryana's irrigated area was only 38% compared to 53% in the rest of Punjab in 1971-72.<sup>49</sup> Yet Haryana too had a remarkable growth in wheat production and productivity (as did Western UP which had few private tubewells) in the late 1960s with an average yield of 1.74 t/ha (with 61% wheatland irrigated) compared to Punjab's 1.87 t/ha (with 71% irrigation) and the all India average of 1.11 t/ha (with 43% irrigation) in the miracle 1967-68 year.<sup>50</sup>

In the long standing rivalry between the Irrigation and Agricultural bureaucracies, the emphasis on issues of quality and plentiful supply<sup>51</sup> served to further the interests of the latter which had gained the upper hand in national priorities in the mid-1960s. Greater coordination between the Agriculture and Irrigation departments had been a standard recommendation of all studies of Indian irrigation beginning from the Indian Irrigation Commission (1901-3) to the studies of utilization of irrigation in the 1950s and beyond. Rarely was this recommendation implemented perhaps in large part due to irrigation engineers' vision of themselves as the custodians of precious water which agriculturalists, and by extension, the agricultural department were unduly extravagant with. This was exemplified by a collaborative experiment in the 1940s between the UP Agriculture and Irrigation Departments to determine optimum water requirements for sugarcane. In the Central Board of Irrigation reports, poor yields were put down to the extravagant use of water by the Agriculture Department which the irrigation staff had been unable to curtail; they promised experiments in subsequent seasons would be carried out with controlled supplies of water.<sup>52</sup> In the 1960s, extravagant use finally found justification with the idea of productive irrigation.

An important study of the effect of source of irrigation on productive agriculture was made by T.V. Moorti of the UP Agricultural University (Pantnagar) in collaboration with JW Mellor of Cornell University as part of the latter's Prices Research Contract with

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<sup>49</sup> From Directorate of Economics and Statistics, *Indian Agricultural Statistics* (New Delhi, 1968-75).

<sup>50</sup> Directorate of Economics and Statistics, *Estimates of Area, Production and Yield of Principal Crops in India* (New Delhi, 1970).

<sup>51</sup> Subramaniam, *Hand of Destiny*, p. 228.

<sup>52</sup> Central Board of Irrigation and Power, *Annual Report (Technical) of the CBIP, 1944* (New Delhi, 1946)



USAID. It studied the performance of state tubewells, private tubewells, Persian wheels and the more traditional *charsa* water lift in Aligarh (UP). Seeking to examine the competition between private tubewells and state tubewells, it concluded that “cultivators prefer to buy private tube well water” even as the study was conducted in two tracts, one with only state tubewell water available, and one with only private tubewell water. The study found that farmers with private tubewells planted three times as much Mexican wheat as those with public tubewells. On *desi* wheat, they applied twice as much fertilizer. Any differences in yield, productivity and fertilizer use were put down to “better control and timeliness of water application” even with no data presented to show whether farmers were indeed getting less water from public tubewells than they demanded. 1966-67 was the first year of the HYV programme, and it was perhaps natural that rich farmers (as reflected in their tubewell ownership) would first take to the new seeds and fertilizers, but the study did not consider the possibility and went to criticize the large losses to the exchequer from public tubewell operation.<sup>53</sup>

The association of tubewells with HYVs and fertilizer usage had to do more with correlation than causation, though this was not often recognized. Tubewell irrigation was seen to play a dual role in the New Agricultural Strategy; as a productive innovation on its own and as a “stimulus to further innovation”.<sup>54</sup> Study after study noted that farmers’ response to the new seeds and increased fertilizer use was critically dependent on whether or not they possessed a tubewell and this made them seem crucial tubewells to the Green Revolution. As mentioned previously, great efforts were made in increasing private tubewell irrigation in the Intensive Agricultural Development Programme (IADP) wheat districts where tubewell technology was cheap and locally well known. This was perhaps less due to any failings of canal irrigation and more due to the extension of irrigation more generally being seen as the most important means of increasing production. The positive results of the IADP in Ludhiana (and to a lesser extent in Aligarh), as compared to rice districts, with the only apparent difference being that the district was primarily irrigated by private tubewells must have contributed to the impression that tubewells were inherently more suited to modern agriculture than canals. When the HYV seeds were first sent out into the field, a guideline to the state governments was that these be preferentially

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<sup>53</sup> T. V. Moorti, *A comparative study of well irrigation in Aligarh District, India* (Ithaca, NY, 1971).

<sup>54</sup> Barbara Harriss, “Innovation Adoption in Indian Agriculture—the High Yielding Varieties Programme”, *Modern Asian Studies* (1972) 6:74.

grown in areas where private irrigation predominated. This might have been because in the early phase, any cultivation of HYVs was something of a demonstration; this was particularly true before 1967-68 when 18% of the wheat area was sown with HYVs.<sup>55</sup> Tubewells were seen as more reliable than canals, and any loss in yield due to delayed irrigation “even if not catastrophic would lead to a loss of confidence” in the new technology.<sup>56</sup>

This psychological aspect was very important; even those who claimed fertilizers produced higher returns than irrigation conceded that possession of irrigation facilities increased the “rate of innovation adoption”.<sup>57</sup> Long before the adoption of HYVs became a sign of the innovative and progressive farmer, construction of wells and tubewells had long been seen as indicative of progressiveness and enterprise. In her study of the late 1950s, tubewells in Punjab and wells in Gujarat, indicative of peasants helping themselves is central to Kusum Nair’s argument about the success of development in these states as compared to some others, where peasants sometimes even refused to take government canal water brought up to their fields. Wells seemed to signify a desire for change so great that expensive private investment was undertaken.<sup>58</sup> Besides the fact that well owning farmers were typically richer (and more able to invest in fertilizer), perhaps it was also the case that tubewell owning farmers were more open to new methods.

That irrigation (of any kind) was central to incentivising improved practices, including the use of fertilizers for the risk averse Indian farmer was old; in fact this was the justification for the large sum spent on irrigation in the First Five Year Plan. But farmers had long complained, even before the HYVs that canal water delivery was inadequate and unreliable, though experts (including not just irrigation engineers) alleged that on the contrary, the Indian farmer was wasteful in his use of water. Private tubewells, by mitigating some of that *perceived* risk in the cultivator’s mind, may have played a role in the adoption of expensive inputs such as fertilizers. But in the ultimate analysis, the chief advantage of the tubewell in the wheat revolution was the same as had been seen by William Stampe in the interwar years; its ability to offer quick expansion of irrigation.

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<sup>55</sup> Harriss, “Innovation Adoption”, p. 82.

<sup>56</sup> Barbara Harriss, “Innovation Adoption”, p. 84.

<sup>57</sup> Barbara Harriss, “Innovation Adoption”, p. 84.

<sup>58</sup> Kusum Nair, *Blossoms in the Dust: The Human Element in Indian Development* (London, 1961), pp. 63 and 121.

### No more gigantism?

The tubewell boom fuelled by the drought and new ideas about irrigation and private initiative was sustained from the late 1960s onwards by loans to cultivators provided by the public sector Agriculture Refinance Corporation with increasing support of the World Bank which I will detail in the next chapter. Groundwater's success in precipitating a Green Revolution attracted many supporters and a key proponent of tubewell irrigation was B.B. Vohra, a civil servant in the Ministry of Agriculture.

Vohra had been instrumental in setting up the Central Groundwater Board attached to the Ministry of Agriculture as a nodal agency to coordinate groundwater development as institutional finance from Indian banks and the World Bank became available for the purpose; he also served as its first chairman. Vohra was known for his popular writings, and one of his first articles, published in 1973 in the *Economic and Political Weekly* titled "A Charter for the Land" is often seen as the first visible sign of official concern at environmental degradation; a concern that led to the setting up of embryonic environmental protection agencies in which Vohra himself played a prominent role.<sup>59</sup> That article, along with his other writings made a case not just for promoting groundwater development but also for an end to large surface irrigation projects.<sup>60</sup>

According to Vohra, India's most pressing problem was to protect the soil and prevent the degradation of the land; water management was key to the same. To protect the soil, it was crucial to prevent erosion by surface run off as well as to prevent waterlogging; both these problems were in large part caused by big dams. According to him, surface water was difficult to store and manage: big projects were expensive, took decades to build, submerged large areas of land, were subject to serious water losses and created significant threats to the very lands they were meant to serve through waterlogging. Further, their storages were threatened by siltation, their command areas were expensive to develop, they entailed high annual financial losses and their operation required large staffs. Yet they could not satisfy the farmer and above all, they were wasteful of water.

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<sup>59</sup> See Ramachandra Guha, *How Much Should a Person Consume?: Environmentalism in India and the United States* (Berkeley, 2006).

<sup>60</sup> See B.B. Vohra, "A Charter for the Land," *Economic and Political Weekly* (1973) 8: A2-A16. Also B.B. Vohra, "No more gigantism," *CERES* (1975) 8:33-35 and B.B. Vohra, "A policy for water," in Indian Society of Agricultural Economics (ed.), *Seminar on Role of Irrigation in the Development of India's Agriculture* (Bombay, 1976).

By contrast, storage of water for indefinite periods in the form of groundwater cost nothing, was not subject to evaporation or seepage losses, and could easily be tapped as individual tubewells within weeks if not days. Once developed it was available as and when required by the mere pushing of a button, lending itself beautifully to modern agriculture.<sup>61</sup> Hence to Vohra, it seemed logical to conserve as much water as possible *insitu* in the form of groundwater, rather than rely on storage in expensive reservoirs. He called for water use to be planned on a sub-catchment basis to ensure that water flowing into rivers (which could be used for storage projects) was not only free from silt but also genuinely surplus to local requirements. By relying on groundwater and intensifying agriculture in its irrigated areas rather than extending surface irrigation; India could raise all its crops on a fraction of the cultivated land, reducing the pressure on its forest and other resources.<sup>62</sup> Thus Vohra called for strong efforts to encourage the development of groundwater resources through land reforms, consolidation of holdings, technical assistance, loan assistance and making sure tubewells did not remain idle for want of power or fuel. It was equally important to promote its recharge, investigate the limits of safe pumping and to legislate on its control.<sup>63</sup>

According to Vohra, what was needed was a vision of water resource management as something inseparable from the overall management of land and soil rather than as a problem of civil engineering alone. The task facing the irrigation departments was to utilize to the fullest possible extent the water that had already been impounded thus far at great cost; a task which would require a drastic reorientation in the attitude of the irrigation engineer. Instead of “dreaming of building more gigantic structures” he would have to undertake the “numberless small works” required to maximize production and prevent the wastage of water and damage to the soil. Fields needed to be reshaped and levelled, distribution systems needed to be extended to so as to reach the last field and adequate drainage works needed to be provided. Emphasis on this comprehensive approach, called Command Area Development would not only lead to better utilization of water but would also induce engineers to take an interest in the problems of siltation and involve themselves in soil and water conservation measures.<sup>64</sup>

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<sup>61</sup> Vohra, “A Charter”, pp. A2-A16.

<sup>62</sup> Vohra, “A Charter”, p. A7.

<sup>63</sup> B.B. Vohra, “A Charter”, p. A9.

<sup>64</sup> Vohra, “A policy”.

While Vohra emphasized that these new challenges stemming from a turn to the small would enhance rather than curtail job opportunities for civil engineers, he did not seek to hide his motive of cutting irrigation departments to size. By forcing Irrigation Departments to confront the total cost of the projects which included Command Area Development, adequate drainage and the protection of reservoirs by afforestation, the new approach would “bring them down to earth - both literally and metaphorically - and dampen their ardour for taking up big projects.” Irrigation Departments “thought it below their dignity to even look at projects costing below Rs. 30 lacs” which were left to local governments and Agriculture Departments; it was precisely these that were most important to Vohra, and irrigation engineers needed to be cured of “the disease of gigantism”.<sup>65</sup>

For a while from the mid-1960s to the mid-1970s, it seemed like this vision of an end to gigantism was coming true. Groundwater became prominent in India’s Five Year Plans from the Fourth Plan onwards, which began after the plan holiday in 1969. It was the first of India’s plans where more money was allocated to minor irrigation and rural electrification than for large schemes; this was in addition to a stimulus for groundwater irrigation in the form of cheap loans from the expanded activities of the Agricultural Refinance Corporation.<sup>66</sup> The increasing unease over the massive losses in irrigation finance, and the feeling that the results were not commensurate had led to the setting up of an Irrigation Commission in the late 1960s. Among the primary recommendations of the Commission was the undertaking of a large-scale programme of Command Area Development, which Vohra had first proposed in 1970 to cut down the irrigation departments to size. Public opinion was also in favour of the agriculture, rather than the irrigation departments. A recommendation, that the Central Groundwater Board be attached with the Ministry of Irrigation rather than Agriculture was criticized in the press as “Undoing the Green Revolution”; irrigation engineers were no longer trusted with the

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<sup>65</sup> Vohra, “A policy”.

<sup>66</sup>Rs. 5.15 billion was allocated for minor irrigation and Rs. 4. 45 billion was allocated for rural electrification to energize pumpsets; making for a total of Rs. 9.60 billion. The allocation for large schemes was marginally lower, with Rs. 7.71 billion being allocated for old schemes and Rs. 1.40 billion for new schemes, in addition to Rs. 420 million for research investigation and design, making for a total of Rs. 9.53 billion. See Planning Commission, *The Fourth Five Year Plan* (New Delhi, 1969), pp. 162-180.

responsibility for food production.<sup>67</sup> The recommendation was never carried out; in fact, recognizing the importance of agricultural expertise in irrigation development, the Department of Irrigation was transferred to the Ministry of Agriculture, and a new Ministry of Agriculture and Irrigation was formed. Finally, the National Development Council (consisting of the chief ministers of the provinces) had adopted a resolution that the irrigation sector must no longer be a burden on the public purse; this resolution carried enough weight to be printed in the Fifth Five Year Plan.<sup>68</sup> Vohra's 1975 article, published in the FAO journal CERES thus bore an optimistic tone, confident that the country's leaders had woken up to the problem of resource management as several hard decisions had already been taken.<sup>69</sup>

And yet, large-scale irrigation projects were back on the agenda in a big way by the mid-1970s. As I argued, irrigated agriculture, even of the kind enabled by canals and deemed as insufficient and inefficient did lead to significantly higher productivity; the characterization of canals as entirely unsuitable for modern agriculture was unfair. Not all areas of the country were suitable for groundwater irrigation and not all farmers could afford the substantial private investment necessary. The applicability of its most successful mode, the tubewell, was largely confined to the Indo-Gangetic plains. Finally, state governments continued to press for large projects, and the established momentum of the irrigation bureaucracies and the entrenched power of what Vohra would later describe as the "contractor mafia" would not falter that easily.

More immediately, the Irrigation Commission, whose recommendations were awaited for planning irrigation policy published its report in 1972. Its boundless faith in the power of science to control nature was reflected in an introductory comment that seasonal shortages could be one day tided over by melting glaciers with nuclear power. With an attitude that natural resources that could be developed must be developed, it recommended a large programme of surface irrigation development to last a few decades. It also recommended the modernization of old canal systems to better serve the needs of the modern agriculture and placed great emphasis on Command Area Development;<sup>70</sup> perhaps there was a hope

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<sup>67</sup> Ashok Thapar, "Undoing the Green Revolution: Tinkering with Groundwater", *Times of India* date April 10<sup>th</sup> 1972.

<sup>68</sup> Planning Commission, *Fourth FYP*.

<sup>69</sup> Vohra, "No more gigantism," pp. 33-35.

<sup>70</sup> Irrigation Commission, *Report of the Irrigation Commission* (Delhi, 1972).

that the irrigation bureaucracy would clean up its act with the new policy. External aid for irrigation also became more freely available; the World Bank began to lend for Command Area Development in the 1970s, enabling new projects by taking up some of the burden of expenditure. After India agreed to go in for International Competitive Bidding, the Bank also began lending large sums to improve the main systems of existing irrigation projects and to new large projects.<sup>71</sup>

Thus together with groundwater development, new large-scale irrigation projects continued to be taken up in the Plans even as lip service was paid to the idea of not taking up new irrigation projects before the old ones were completed. Performance continued to be below expectations; in 1986, Prime Minister Rajiv Gandhi echoed his grandfather's words from nearly 30 years ago in a speech to a State Irrigation Ministers' Conference,

The situation today is that since 1951, 246 big surface irrigation projects have been initiated. Only 65 of these have been completed. One hundred and eighty one are still under construction... Perhaps we can safely say that no benefit has come to the people from [Post 1970 projects]. For 16 years we have poured money out. The people have got nothing back: no irrigation, no water, no increase in production, no help in their daily life.<sup>72</sup>

From the late 1970s, a popular movement against big dams began in India. The movement had its first success in 1983 when, at Indira Gandhi's instance, a hydroelectric project in the Silent Valley was abandoned and the area was declared a National Park. Vohra, who served in the early 1980s as the Chairman of the new National Committee on Environmental Planning lent his support to the rising activism, terming the havoc played by large irrigation schemes as "one of the greatest unrecognized environmental problems in the world".<sup>73</sup> The anti-dam movement picked steam through the 1980s with the Sardar Sarovar Project on the Narmada and the Tehri hydroelectric project on the Bhagirathi dominating the discourse. Writing in a non-official capacity, Vohra became perhaps the most senior establishment figure crusading against big dams in the popular press.<sup>74</sup> An

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<sup>71</sup> Robert Wade and Robert Chambers, "Managing the Main System: Canal Irrigation's Blind Spot," *Economic and Political Weekly* (1980), 15: A107-A112

<sup>72</sup> As quoted in BB Vohra, "Irrigation of the Nation", *Himal Southasian* August 1996.

<sup>73</sup> William Clairborne, "India's canal projects bog down in bad drainage", *The Montreal Gazette* 27<sup>th</sup> April 1983.

<sup>74</sup> Besides several articles in the press, see BB Vohra, *Land and Water: Towards a Policy for Life-support systems* (New Delhi, 1985), BB Vohra, *The greening of India* (New

important opponent of his arguments was BD Dhawan, a pioneering economist of groundwater irrigation in India. Dhawan argued that both major and minor irrigation was necessary; a full accounting of the public and private costs of groundwater irrigation would prove that tubewells were not as cheap as they seemed. In addition, big dams enabled cheaper withdrawal of groundwater due to a rise in the water table as a result of seepage from canals.<sup>75</sup>

The extent to which these considerations played a part in the continued momentum of the large-scale irrigation sector in the 1980s is not known. But fresh investment in the major and medium irrigation sector finally slowed down in the 8<sup>th</sup> Five Year Plan (1992-97) when only one new project was to be taken up (though two eventually were). Large-scale irrigation systems had suffered their first setback during the economic crisis and partial liberalization of the Indian economy between 1966 and 1969. It was perhaps entirely appropriate that the slowing down in the 1990s came in the aftermath of the economic crisis and liberalization of the economy in 1991. The Eight Five Year Plan (1992-97) neatly summarized the experience of planning irrigation in independent India as follows,

The biggest single malady in the major and medium irrigation sector right from the First Plan has been the continued tendency to start more and more new projects resulting in wanton proliferation of projects, thin spreading of resources and consequent time and cost overruns. Though all the Plans, without exception, declared their intention to give priority to complete the ongoing schemes, the addition of new schemes continued unabated.<sup>76</sup>

## Conclusion

Despite criticism of the low returns on investment in large-scale irrigation systems in India, according to the experts who were part of the World Bank Bell Mission, irrigation continued to be the most important input to Indian agriculture, particularly as it enabled the full benefit of fertilizers. It argued for a change in emphasis in favour of perennial, assured irrigation to enable multiple cropping and intensive water use. The experts felt that this was not possible in the case of government controlled irrigation sources as their

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Delhi, 1985) and BB Vohra, *The Management of Natural Resources* (New Delhi, 1987); all directed at a general audience.

<sup>75</sup> These arguments are summarized in BD Dhawan, *Big Dams: Claims and Counter Claims* (New Delhi, 1989).

<sup>76</sup> Planning Commission, *The Eight Five Year Plan* (New Delhi, 1992), p. 163.



social welfare objectives led them to maximize the area of land irrigated with a fixed amount of water. This conflicted with the strategy of the individual cultivator, who, having a fixed amount of land, sought to maximize water input to increase his profit. Even as it was acknowledged that maximizing the area served was the best use of scarce natural resources from both a social and production-maximization point of view, it felt that a plentiful, assured supply of water free of government control was the key to promote multiple cropping and the use of other riskier inputs such as fertilizers by the cultivator. Based on this vision of a conflict between a self-interested cultivator and the social good, it placed the former on a pedestal and argued that private tubewells were the way forward to maximizing yields, implicitly assuming that the problem of equitable distribution did not exist in the case of groundwater.

This advice came at a time of almost unprecedented drought in India which demanded quick creation of capacity for irrigation. Private tubewells were well suited as the solution and these were promoted through loans, subsidies and rural electrification; more was spent on the latter between 1966 and 1969 than had been spent in the preceding fifteen years. At the same time, the optimization of irrigation schedules for the dwarf wheat varieties in the late 1960s suggested that tubewells were better suited for the needs of modern agriculture than canals. However, the marginal advantages of tubewells over canals played a minor role in increased productivity than the quick leap from rainfed agriculture to irrigation (of any sort) offered by tubewells; well managed canal systems held their own when it came to increasing yields. The most important reason for policy to favour tubewells was the correlation between tubewell ownership and higher fertilizer use which had more to do with mitigating perceived risk in the cultivator's mind as well as the general larger resources of tubewell owning farmers.

Tubewells made a substantial contribution to the Green Revolution. Big dam projects on the other hand seemed mired in financial and capacity utilization problems which largely had to do with a thin spread of resources. Thus in the early 1970s, many called for an end to the era of the large dam, seeing the tubewell as an alternative. India however continued to build large canal systems while also enabling and subsidizing private tubewells despite much criticism of the former as inefficient, environmentally damaging and unsuited to modern agriculture. This was due to several reasons, including the unsuitability of

tubewells in large parts of India, the availability of World Bank loans for big dams as well as the established momentum of the irrigation bureaucracy.

## Chapter 7: Financing a Tubewell Boom

Histories of late twentieth century Indian agriculture typically focus on two sets of institutions. On the one hand are Indian government organizations such as the agricultural research system and government ministries. On the other hand, they also tell the story of international actors such as the American government and the Ford and Rockefeller Foundation.<sup>1</sup> In this chapter, I shall tell the story of a third kind of development institution. At the domestic level, this institution was the public sector finance company; the Agricultural Refinance Corporation (ARC). At the global level, this institution was the World Bank whose hands on role in what is called the Green Revolution is scarcely known.

As mentioned in the last chapter, the World Bank's Bell Mission (1964-65) had successfully pressed for an irrigation policy focused on private tubewells. In this chapter, I will show how the government began a programme of supporting bank loans to cultivators for groundwater development through a public sector company called the Agricultural Refinance Corporation (ARC)<sup>2</sup> in the late 1960s. This programme was massively scaled up with World Bank aid from 1970 onwards and the ARC became the largest financier of private groundwater development in India.

I shall argue that the sacrifice of equity was a conscious choice of elite development actors. Irrigation facilities could be publicly owned with the objective of both increased production and social equity, or privately owned with the objective of profit maximization. The World Bank explicitly favored and promoted the latter and influential Indian bureaucrats were also in favour of promoting private tubewells, though their reasons had as much to do with the paucity of public finance for irrigation as with any inherent advantages of private tubewells. I shall demonstrate that these elite development actors were well aware of the potential impact of their choice on rural inequality. While they tried to take steps to target loans to the poor through policy changes that made the

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<sup>1</sup> See for example John Perkins, *Geopolitics and the Green Revolution: Wheat Genes and the Cold War* (New York, 1997) and Nick Cullather, *The Hungry World: America's Cold War Battle against Poverty in Asia* (Cambridge, Ma, 2010).

<sup>2</sup> The corporation was renamed the Agricultural Refinance and Development Corporation (ARDC) in 1975 and reconstituted in 1982 in its present form the National Bank of Agriculture and Rural Development (NABARD). However the name ARC is used throughout this chapter.

programme very similar to what is today called microfinance, their attempts to ensure equitable access to groundwater resources had a limited impact, in large part due to their bias in favor of individual, rather than cooperative or public ownership of tubewells.

## I

The World Bank's role in Indian agricultural development, while hinted as being significant, is not fully known. In his diplomatic history of the Green Revolution, Cullather mentions that the World Bank doubled loan outlays to India and Pakistan after the 1968, quoting McNamara as to how the miracle harvest had dispelled institutionalized confusion as to what had gone wrong with development efforts in the past and what the path ahead should be. He then quickly shifts to the turn to the "Basic needs paradigm" that focused on social goods such as education and healthcare, neglecting the Bank's activities centered on agricultural production.<sup>3</sup>

Secondly, we have the literature on the World Bank and the International Development Association, one of its constituents. The official history tells the story of Bank's turn toward supporting agricultural projects in the 1960s; the largest and earliest receiver of such loans was India.<sup>4</sup> Goldman's recent work on the International Development Association is focused on lending to poor world governments for large state-controlled water resource development projects with a large foreign exchange component, unlike the lending programmes targeted at private individuals for investment largely in local currency studied in this chapter. More generally, Goldman and others have focused on big dam projects pushed by the World Bank through loans to governments; rather than on the Bank's substantial lending to cultivators (through domestic financial institutions) for small well projects.<sup>5</sup>

Besides government publications and the memoirs of the civil servant B. Sivaraman, this chapter draws from two key sets of sources. The first are printed reports of the World Bank; these include annual commentaries on the state of the Indian economy titled *India - Current economic position and prospects* (or variant thereof) written in by consultants and the Bank's South Asia Department, the report of the World Bank's 1964-65 study of

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<sup>3</sup> Cullather, *Hungry World*, p. 236.

<sup>4</sup> Devesh Kapur, John Prior Lewis, and Richard Charles Webb, (eds.) *The World Bank: Its First Half Century. Volume. 1: History* (Washington, DC, 1997), pp. 385-390.

<sup>5</sup> Michael Goldman, *Imperial Nature: The World Bank and the Struggles for Social Justice in the Age of Globalization* (New Haven, Ct, 2005).

the Indian economy headed by Bernard Bell an external consultant, as well as *Staff Appraisal Reports* for particular loans extended to India which contain key information about the loans and the conditions attached. Usually stamped *Confidential* or *Restricted*, these were largely for internal use, though they would have been shared with key Indian agencies and officials who provided inputs for their preparation. The other set of sources for this chapter are publications of the Agricultural Refinance Corporation, such as annual reports, key circulars and evaluation studies which were sourced from the library of its successor institution, the National Bank for Agriculture and Rural Development in Mumbai.

### **The Agricultural Refinance Corporation and groundwater irrigation**

A key agency in promoting private tubewell irrigation was the Agricultural Refinance Corporation which was set up in 1963 to support the agricultural lending programmes of banking institutions. Credit had long been seen as an important bottleneck for agricultural improvement in India. During the Raj, a system of *taccavi* loans had been set up. This was supplemented by the rise of various formal banking institutions such as cooperative and land mortgage banks, though the overwhelming majority of credit was still provided by the local moneylender. The setting up of the ARC was a step to support formal banking institutions in making credit for agricultural investment more easily available. Such a financial development corporation had precedents in the Indian subcontinent. For the industrial sector, the World Bank had financed the setting up of the Industrial Credit and Investment Corporation of India in the 1950s. Pakistan had set up the Agricultural Development Finance Corporation in 1952, motivated in large part by the mass migration of Hindu moneylenders during Partition.<sup>6</sup>

The Agricultural Refinance Corporation (ARC) was founded in 1963 by an Act of Parliament to support the financing of agriculture. It had an authorized share capital of Rs. 250 million (about \$ 52.5 million) of which Rs. 50 million (about \$ 10.5 million)<sup>7</sup> was to be fully paid up to begin with by the Reserve Bank of India (RBI), cooperative and commercial banks, and other financial institutions such as the Life Insurance

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<sup>6</sup> Mumtaz Mirza, "The Pakistan Agricultural Development Finance Corporation", *Middle East Journal* (1958) **12**: 324-332

<sup>7</sup> Exchange rates are as per World Bank, *Economic Situation and Prospects of India* (Washington, DC, 1964). Subsequent exchange rates are from the same publication of the appropriate year.

Corporation of India (LIC); a minimum dividend was guaranteed by the government. It was governed by a board consisting of three nominees of the Government of India, one by the RBI, one by the land mortgage banks, one by cooperative banks and one by other shareholders such as the LIC. A deputy governor of the RBI was to be the chairman of the board and the Managing Director was to be appointed by the Reserve Bank of India.<sup>8</sup>

In its own words, its job was to refinance the preparation of land for irrigation; the development of plantation crops such as arecanut, coconut, cashew nut, cardamom, coffee and tea; the development of mechanized farming and the use of electricity for tubewells and pump sets; and the development of animal husbandry, dry farming, pisciculture and poultry farming.<sup>9</sup> It was permitted to raise money up to twenty times the paid up capital by borrowing from the government, the Reserve Bank and from the market by issuing bonds and debentures. With this money, it was to support loans to cultivators for capital investment in agriculture by buying debentures issued by cooperative banks, land mortgage banks<sup>10</sup> and scheduled banks to finance their lending programmes in case of “compact and worthwhile schemes of agricultural development with the economics thereof clearly proved”.<sup>11</sup>

Despite the mention of tubewells and pumpsets as one of its main areas of activity, it did not fund any minor-irrigation schemes in the first four financial years of its existence. The focus had been on the preparation of land for major irrigation schemes, plantations, horticulture and other cash crops.<sup>12</sup> But B. Sivaraman, the secretary of the Ministry of Agriculture, who was one of the directors of the Corporation, saw the importance of irrigation-expansion. According to him to the New Agricultural Strategy which he had co-written “was based on irrigation”, even fertilizers were merely “another aspect of the

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<sup>8</sup> Government of India, *Agricultural Refinance Corporation Act* (New Delhi, 1963)

<sup>9</sup> Agricultural Refinance Corporation, *Annual Report 1963-64* (Bombay, 1964), p.1.

<sup>10</sup> Land Mortgage Banks, also referred to as Land Development Banks were also cooperatives. Unlike “cooperative banks” which mostly financed small short term loans, they financed capital investment with larger loans on longer terms.

<sup>11</sup> ARC, *Report 1963-64*, p.1.

<sup>12</sup> From ARC, *Reports 1963-67*.

programme”.<sup>13</sup> Sivaraman was a great proponent of private tubewells for two sets of reasons. The first which he articulated in a lecture to trainee administrators in 1970 was the limitation of public finance. In the first three five year plan plans, irrigation investment had largely been in the state sector and was limited by plan allocations; subsidies for private pumps had been limited by the surplus in the revenue accounts of budgets. Turning the programme over to the private sector supported by loan financing enabled the programme to be “multiplied manifold”.<sup>14</sup>

The other reason was on the lines of Hopper’s thinking which emphasized the tubewell as an enabler of profit-seeking agriculture; this was emphasized in his memoirs. Sivaraman argued that a rapid increase in irrigated area would be crucial for increasing yields as planned in the new agricultural strategy. As per his account, statistics showed that cropping intensities on canal-irrigated land were only marginally higher than on rain-fed land, and studies in Western UP had demonstrated that the farmer’s profit from private tubewells and government tubewells was six times and two times respectively the profit from government controlled surface sources. According to Sivaraman, “The method for maximizing yields was staring us in our face.”<sup>15</sup> Profits, cropping intensities and yields of course don’t necessarily map into one another. But these statistics provided an empirical basis for the apotheosis of the private profit motive as a means to increasing production that was central to the ideology of the New Agricultural Strategy. It seemed clear that private investment in irrigation would yield the quickest return and the government’s task was to provide farmers with the necessary credit.<sup>16</sup>

However, Sivaraman felt that the existing cooperative credit system could not handle the large sums involved on its own. By his account, on being pressed for the ARC’s involvement, its chairman Dr. D.R. Gadgil (an economist who had conducted a pioneering study of costs and benefits of large irrigation projects published in 1948<sup>17</sup>) claimed that that the states should finance minor-irrigation schemes; this was not the

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<sup>13</sup> B. Sivaraman, *Address by Shri B. Sivaraman on Collector's Role in Indian Agriculture at the National Academy of Administration, Mussoorie, on 14th May, 1970* (New Delhi, 1970), p.7.

<sup>14</sup> B. Sivaraman, *Address*, p.7.

<sup>15</sup> B Sivaraman, *Bitter Sweet: Governance of India in Transition* (New Delhi, 1991), pp. 404.

<sup>16</sup> Sivaraman, *Bitter Sweet*, pp. 405.

<sup>17</sup> D.R. Gadgil, *Economic Effects of Irrigation* (Poona, 1948).

responsibility of the ARC or the cooperative banking system.<sup>18</sup> This was strange as tubewells had been mentioned as being a part of the ARC's remit in its very first annual report.<sup>19</sup> However, as a result of pressure exerted by Sivaraman, it was agreed that groundwater development would be pursued as a trial. According to Sivaraman, the Corporation's Managing Director, civil servant M.R. Bhide, having been secretary of the Department of Cooperation "had very ancient ideas" about cooperatives,<sup>20</sup> which is perhaps why, in September 1965 the corporation merely clarified that while ARC finance would not normally be available from the ARC for well construction, the ARC would be willing to consider schemes where "large sums are involved and the schemes are prepared for a compact area through the formation of irrigation cooperatives instead of leaving the development to take place through individual efforts alone."<sup>21</sup> Bhide's successor P.N. Damry, however presented no such trouble<sup>22</sup> and "at the instance of the Government of India" the ARC agreed to consider lending schemes relying on individual efforts.<sup>23</sup>

Thus cooperation, the rhetorical centerpiece of Nehruvian agrarian strategy was near-officially discarded within a couple of years of the leader's passing, in keeping with the new agricultural strategy's larger sacrifice of equity in favor of higher productivity. In a telling comment on the lack of cooperation between farmers which had defeated the modernization of the ancient Cauvery delta irrigation system, Sivaraman rued the fact that, "the idea of a common good has no meaning in a democracy. It is the individual and his selfishness that ultimately counts."<sup>24</sup>

1967-68 was the first year in which the Corporation financed groundwater irrigation. In the four years ending in June 1967, the ARC had sanctioned a total of 39 schemes having

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<sup>18</sup> Sivaraman, *Bitter Sweet*, p. 405.

<sup>19</sup> ARC, *Report 1963-64*, p.1.

<sup>20</sup> Sivaraman, *Bitter Sweet*, p. 406. The ancient ideas that Sivaraman refers to may be the notion that irrigation facilities should be state owned or cooperatively owned.

<sup>21</sup> Circular No. OPS. 794/L-1-65/66 from V Sivaraman, Managing Director to All Eligible Institutions dated 10 September 1965.

<sup>22</sup> B Sivaraman, *Bitter Sweet*, p. 406.

<sup>23</sup> ARC, *Report 1965-66*, pp. 9-10.

<sup>24</sup> Sivaraman, *Bitter Sweet*, p. 407.



a total outlay of \$ 51.2 million (of which its own commitment was \$ 40.7 million).<sup>25</sup> In the year 1967-68 alone, it sanctioned 89 schemes totaling \$ 88.6 million (of which its own commitment was \$ 76.2 million). Of these, 54 schemes were for minor irrigation and had a total outlay of \$ 68.6 million (of which its own commitment was \$ 61.1 million).<sup>26</sup> To put it simply, in the very first year the corporation began financing groundwater irrigation, the outlay on it accounted for nearly four fifths of the total outlay that year, nearly half of the total outlay on projects sanctioned by it in its five year existence and more than the total amount sanctioned in the previous four years. These 54 schemes which lay in Andhra Pradesh, Bihar, Delhi, Gujarat, Haryana, Madras, Maharashtra, Mysore, Madhya Pradesh, Punjab, Uttar Pradesh and West Bengal envisaged a total of 59,981 wells and tubewells together with 40,845 pump sets. ARC support for groundwater development was to rise in subsequent years and by the financial year ending in 1975, its commitment to minor irrigation accounted for \$ 600 million, over three fourths of its total commitments.<sup>27</sup> Lending to groundwater development was initially seen as a diversification of the corporation's business,<sup>28</sup> even as it arguably became its core business in the very first year. But by the early 1970s, the phrase "diversified lending" would actually come to refer explicitly to lending for any purpose but groundwater development.<sup>29</sup> Tubewells, dugwells and pumps were clearly where the largest demand for long-term private investment in rural India lay.

By mid-1980, the ARC had financed 325,000 tubewells, 523,000 dugwells and 755,000 electric or oil engine pump sets. By the year 1977, for which we have an estimate of the total groundwater-extraction structures in India, it had financed 254,300 tubewells (close to 15% of a total of 1,744,300 tubewells then extant in India) and 390,000 dugwells (5% of a total of 7,691,700).<sup>30</sup> This was in addition to a growing share of tubewells financed by commercial banks after their nationalization in 1969, initially through a joint company

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<sup>25</sup> The rupee figures are Rs. 39.41 crores and Rs. 31.95 crores respectively converted at the 1968 exchange rate of Re 1=US \$ 0.13.

<sup>26</sup> Compiled from ARC, *Reports 1964-68*.

<sup>27</sup> Compiled from ARC, *Report 1974-75*.

<sup>28</sup> ARC, *Report 1967-68*.

<sup>29</sup> See for example, ARC, *Report 1972-73*, p. 5.

<sup>30</sup> ARC, *Report, 1976-77 & 1979-80* and B.D. Dhawan, "Trends in Tubewell Irrigation, 1951-78", *Economic and Political Weekly* (1978) 14: A143-A154.

confusingly called the Agricultural Finance Corporation, and later with each bank operating on its own. As is well known, institutional finance has a very low penetration in India with most capital raised from family and money lenders; it is safe to say that modest as its contribution was, the ARC was the largest financier of groundwater investments in India. Ever the eulogist of private enterprise, Sivaraman in fact saw the small share of government supported systems as reason to celebrate farmers' initiative, citing a case in Karnataka where farmers had sunk 7000 wells even as government supported loans had only financed 300 as a "symbol of the farmers' contribution to the Green Revolution."<sup>31</sup>

### **Channelizing World Bank Money to the Cultivator**

By 1968, the year the term "Green Revolution" was coined and the first productivity gains of the strategy had been proven in India, the World Bank's report on India's prospects identified irrigation and farm credit as important bottlenecks for the expansion of the strategy. As smaller farmers entered productive agriculture, credit requirements for tubewell development would grow, and efforts were needed to both increase the flow of institutional credit and to strengthen cooperative banks in states where they were weak. It also felt that maximum groundwater development could only be safely approached with a precise evaluation of water resources; a thorough study of India's aquifers "was long overdue".<sup>32</sup>

In the next year, the chapter on agriculture had a section titled *The Water Constraint*, the only farm input with so ominous a title. It noted that with the exception of northern India, lack of adequate water control had turned out to be an important obstacle to the penetration of the new technology, and expensive canal systems continued to fail in delivering timely supplies of water. This called for more investment, research into better utilization of water in the fields, research in well design and a better understanding of the aquifers.<sup>33</sup> In the same volume, a section titled *The "Other" Cultivators* emphasized that

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<sup>31</sup> Sivaraman, *Bitter Sweet*, p.407.

<sup>32</sup> World Bank. 1968. *India - Current situation and short term prospects*. Asia series; no. AS 131 (Washington, DC, 1968), p. 15-17. Accessed online at <http://documents.worldbank.org/curated/en/1968/01/1559609/india-current-situation-short-term-prospects> on 23rd February 2015.

<sup>33</sup> World Bank, *India - Economic situation and prospects*. South Asia series; no. SA 3 (Washington, DC, 1969) World Bank, pp. 18-20. Accessed online at

the elements of the new technology included not only seeds and fertilizers but also adequate water and water control; the latter “severely circumscribes the area suitable for technological breakthrough” and would exclude 80% of the cultivators from the Green Revolution’s benefits.<sup>34</sup> A “kind of trichotomy” was developing in rural India, consisting of large farmers, small farmers who were nevertheless physically well situated to exploit surface or groundwater with some assistance and finally, small cultivators outside the “favored water regions” who could only be helped with research into dry farming.<sup>35</sup> It was the second category (of small farmers in water favored regions) who could be substantially helped to participate in the Green Revolution with credit, extension and land reform.<sup>36</sup>

The Bank did not have a strong tradition of lending for agriculture or small-scale irrigation development in India. Since its inception up until the late 1960s, the World Bank had financed about 60 projects in India. While the second loan to be approved in 1949 had been for the reclamation of three million acres of land, projects of an industrial nature dominated the Bank’s programme in India until the end of the 1950s; covering sectors such as railways, power, aviation, steel, ports and industrial credit. The sole exception was a loan to part finance the Damodar Valley Corporation, the first of the multipurpose river valley development projects taken up by independent India which included both power production and irrigation.<sup>37</sup> The Bank’s support for agriculture in India through the financing of irrigation picked up in the early 1960s with the formation

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<http://documents.worldbank.org/curated/en/1969/04/1555527/india-economic-situation-prospects> on 23rd February 2015.

<sup>34</sup> World Bank, *India - Economic situation and prospects*. South Asia series; no. SA 3 (Washington, DC, 1969) World Bank, p. 25.

<sup>35</sup> World Bank, *India - Economic situation and prospects*. South Asia series; no. SA 3 (Washington, DC, 1969) World Bank, p. 26.

<sup>36</sup> World Bank, *India - Economic situation and prospects*. South Asia series; no. SA 3 (Washington, DC, 1969) World Bank, p. 26.

<sup>37</sup> Compiled from the World Bank projects website <http://www.worldbank.org/projects> accessed on 23rd February 2015.

of the International Development Association (IDA)<sup>38</sup> which financed some projects in Gujarat, Orissa, Bihar and Maharashtra in the early 1960s.<sup>39</sup>

As mentioned in Chapter 4, the International Bank for Reconstruction and Development (IBRD) had rejected India's proposal for a loan to finance a public tubewell project in the late 1940s on the grounds that India's groundwater resources had not been sufficiently surveyed. The Bank in its early years was however not altogether uninterested in groundwater irrigation; in 1951, it granted a \$1.3 million loan to the government-owned Fomento Corporation in Chile for a groundwater exploration and development project in the Rio Elqui valley. The circumstances surrounding this loan differed significantly from the Indian project in as the development phase of the project would not go forward unless adequate supplies were proven by investigations, and the fact that the enhanced food production would be in a mining district and hence of strategic importance to the national economy.<sup>40</sup> There was a long lull in the World Bank's engagement with groundwater irrigation until a \$ 3.7 million loan was sanctioned by IDA to Taiwan for a tubewell scheme in 1961.<sup>41</sup> This was closely followed in the same year by a \$ 6 million loan to Uttar Pradesh (UP, formerly United Provinces) which was the first IDA project in India. The loan was to finance the expansion of UP's public tubewell programme to irrigate a further 320,000 acres with tubewells of "virtually the same" design and specifications as the William Stampe scheme of the 1930s.<sup>42</sup>

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<sup>38</sup> The World Bank group presently consists of the IBRD (which lends to low and middle income countries), the IDA (founded in 1960 which gives interest free loans to the "poorest countries" using donor country resources rather than money raised on the markets), the International Finance Corporation, The Multilateral Investment Guarantee Agency, and the International Centre for Settlement of Investment Disputes.

<sup>39</sup> Compiled from the World Bank India Projects Website.

<sup>40</sup> World Bank, *Chile - Technical report on development of groundwater resources of the Rio Elqui Groundwater Resources Project*. Loan series; no. L 136. (Washington, DC, 1951). Accessed online at <http://documents.worldbank.org/curated/en/1951/08/1558351/chile-technical-report-development-groundwater-resources-rio-elqui-groundwater-resources-project> on 23rd February 2015.

<sup>41</sup> World Bank, *China - Ground Water Development Project* (Washington, DC, 1961). Accessed online at <http://documents.worldbank.org/curated/en/1961/08/1554265/china-ground-water-development-project> on 23rd February 2015.

<sup>42</sup> World Bank, *India - Uttar Pradesh Tubewell Irrigation Project* (Washington, DC 1961), p. 2. Accessed online at

Having encouraged private tubewells in India with its advice in the mid-1960s, the World Bank did not immediately put its money where its mouth was. In fact, according to Sivaraman, the World Bank had refused credit for a massive tubewell-irrigation project in eastern UP in 1965, on the ostensible grounds that granting a loan might be seen as taking sides in the dispute over Ganges waters with (East) Pakistan as the development would be in the Ganges Valley.<sup>43</sup> The excellent wheat harvest of 1968, with tubewells playing a large part in the same must have played a role in the process of softening the World Bank towards agricultural projects which was taking place in the 1960s; clearing institutional confusion by illustrating a possible route to success. In late 1968, an IDA mission visited India to review agricultural credit institutions and identify high priority farm investments in the country with the assistance of the FAO.<sup>44</sup> According to Sivaraman, the real turn took place in 1970, when during a visit to India, Robert McNamara was impressed with the impact of tubewell development in Purnia (Bihar) and declared the Bank's intention to support India's groundwater programme,<sup>45</sup> but loans for groundwater were already in the pipeline by this point.

The first World Bank-ARC projects began in 1969-70 for the production of high quality seeds in the Tarai region (\$ 14. 61 million, of which the IBRD contributed about half), credit to farmers in Gujarat (\$ 35 million provided by IDA which was equivalent to \$7.7 million of the foreign exchange and about half of the rupee costs. Of this \$27.3 million was for minor irrigation) and the Punjab project (\$ 27.5 million from IDA for tractors and harvesters). The money would be extended to the Government of India which would lend it to the Agricultural Refinance Corporation (ARC) on standard terms, and they would disburse the money to Land Development Banks for lending to cultivators.<sup>46</sup> These were

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<http://documents.worldbank.org/curated/en/1961/08/1554253/india-uttar-pradesh-tubewell-irrigation-project> on 23rd February 2015.

<sup>43</sup> Sivaraman, *Bitter Sweet*, p. 410.

<sup>44</sup> World Bank, *India - Gujarat Agricultural Credit Project*. Agriculture projects series; no. PA 34 (Washington, DC, 1970), p. 1. Accessed online at <http://documents.worldbank.org/curated/en/1970/04/722553/india-gujarat-agricultural-credit-project> on 23rd February 2015.

<sup>45</sup> Sivaraman, *Bitter Sweet*, p. 410.

<sup>46</sup> Compiled from the staff appraisal reports: World Bank, *India - Gujarat Agricultural Credit Project*. Agriculture projects series; no. PA 34 (Washington, DC, 1970), p. 1. World Bank, *India - Terai Seeds Project*, Technical operations projects series; no. TO 689 (Washington, DC, 1969). Accessed online at

quickly followed by eighteen other projects to be executed by the ARC, one of which was for agro aviation (and was later dropped), two for the development of market yards, three for dairy development, one for apple development and the rest were for crop agriculture. While only over a third of the bank's contribution to the first four schemes was for minor irrigation, the latter quickly constituted the lion's share of the loans for crop agriculture (see Table 7.1).

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<http://documents.worldbank.org/curated/en/1969/05/1554290/india-tarai-seeds-project-india-terai-seeds-project> on 23rd February 2015. World Bank, *India - Punjab Agricultural Credit Project*. Agriculture projects series; no. PA 48 (Washington, DC, 1970). Accessed online at <http://documents.worldbank.org/curated/en/1970/05/722537/india-punjab-agricultural-credit-project> on 23rd February 2015.

Year of Sanction	Project	Cost (\$ million)	IDA's Contribution (\$ million)	Minor irrigation component of project (Percentage)	Proportion of IDA's contribution earmarked for minor irrigation (Percentage)
1970-71	Andhra Pradesh	45	24.4	59	57
1970-71	Haryana	44.5	25	27	18
1970-71	Tamil Nadu	62.3	35	70	65
1971-72	Maharashtra	52.4	30	79	76
1971-72	Mysore	75.4	40	34	50
1972-73	Uttar Pradesh	72.5	38	100	100
1972-73	Madhya Pradesh	60.3	33	96	95
1973-74	Chambal Command Area Development	12	5	0	0
1973-74	Rajasthan Canal Command Area Development	39.8	12.1	0	0
1973-74	Bihar	60	32	100	100
1974-75	West Bengal	67	34	60	59
<b>Total</b>		<b>591.2</b>	<b>308.5</b>	<b>64</b>	<b>64</b>

**Table 7.1: World Bank loans to the ARC for crop agriculture, 1970-75.**

**Source:** Compiled from Agricultural Refinance Corporation, *Annual Reports 1970-75* (Bombay, 1970-75).

Minor irrigation did much better than the other sectors in terms of actual disbursements as a proportion of the outlay; in fact IDA credit meant for other purposes was being diverted to minor irrigation by 1973-74,<sup>47</sup> again demonstrating the central role of groundwater in the rural credit economy. However, World Bank funding to the ARC for irrigation activities, while overwhelmingly focused private tubewells, pumps and wells, it was not restricted to these. From the mid-1970s the Bank also began to lend to the ARC for India's Command Area Development programme, which was aimed at building the

<sup>47</sup> ARC, *Report 1973-74*, p. 12.

field channels for the last-mile delivery of water for various projects. After 1979, when India agreed to the concept of International Competitive Bidding, the Bank also began to fund improvements to the main canal system of various projects.<sup>48</sup>

In 1973-74, the ARC submitted a proposal for a large all India project which was accepted by IDA during the next year. This was distinct from other IDA projects as the responsibility for identifying and appraising schemes and committing funds was left to the ARC. The eventual loan was for \$75 million of which \$69 million was to be allocated to minor irrigation. This was followed by a second general line of credit for \$200 million in 1977 (the total cost of the project was \$ 583million of which 75% was for minor irrigation. A further \$1 million was for a study of groundwater resources), a third line in 1979 for \$ 250 million (total project cost of \$ 1005 million of which about half was to be for minor irrigation) and a fourth line of credit of \$350 million (total project cost of \$2086 million of which about 60% was for minor irrigation).<sup>49</sup> General line of credit loans continued to be extended by the World Bank into the 1980s when the ARC was merged with the Agricultural Credit Department of the Reserve Bank of India to form the National Bank for Agriculture and Rural Development (NABARD). While there was indeed diversification from a focus on groundwater alone, the latter continued to be central to the rural credit economy.

### **A typical groundwater credit scheme**

The World Bank placed great emphasis on the techno-economic evaluation of the cultivator's profit from its projects, and lamented the fact that none of the directors of the ARC had degrees in agricultural engineering or agricultural economics. The Bank also

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<sup>48</sup> Robert Wade and Robert Chambers, "Managing the Main System: Canal Irrigation's Blind Spot", *Economic and Political Weekly* (1980) **15**: A110.

<sup>49</sup> Compiled from Staff Appraisal Reports for various projects: World Bank, *India - Agricultural Refinance Corporation Credit Project* (Washington, DC, 1975) Accessed online at <http://documents.worldbank.org/curated/en/1975/03/724996/india-agricultural-refinance-corporation-credit-project> on 23rd February 2015. World Bank, *India - Second Agricultural Refinance and Development Corporation Credit Project* (Washington, DC, 1977). Accessed online at <http://documents.worldbank.org/curated/en/1977/05/727264/india-second-agricultural-refinance-development-corporation-credit-project> on 23rd February 2015. World Bank, *India - Third Agricultural Refinance and Development Corporation Credit Project* (Washington, DC, 1979). Accessed online at <http://documents.worldbank.org/curated/en/1979/06/726612/india-third-agricultural-refinance-development-corporation-credit-project> on 23rd February 2015.



emphasized studies that evaluated the economic impact of the ARC's schemes;<sup>50</sup> an evaluation cell was set up in the ARC and starting in 1977 it published several "ex-post evaluation studies" of various local schemes. These studies provide much information on the working and impact of groundwater credit schemes and were quoted in World Bank loan appraisal reports to assure lenders of the viability of the new sector.<sup>51</sup>

Among the first four schemes taken up for study was one for the installation of 3,600 tubewells in Karnal (in Haryana) between 1967 and 1972 through credit extended by the Haryana State Cooperative Land Mortgage Bank. This scheme, which was approved for refinance by the ARC board in September 1967 was to be supervised by the deputy state director of agriculture in charge of the Intensive Agricultural District Programme. A farmer seeking a loan to sink a tubewell was to become a member of the cooperative bank by purchasing one share of Rs. 100 and was to subsequently purchase additional shares to the extent of 5% of the loan sought. The loan was typically for between five and seven thousand rupees, carried an interest of 7.75%, was to be paid back in six annual installments beginning from the second year and secured by mortgaging land of twice the value of the loan.<sup>52</sup>

The impact of the scheme demonstrated that while tubewells did greatly enhance production and cultivator incomes, this was nowhere close to the spectacular assumptions made while drawing up the schemes. While each tubewell was to irrigate 10-15 acres with a discharge of 0.5 cusec,<sup>53</sup> the actual irrigated area was only about 9 acres; this was attributed by the evaluation study to the fact that the actual discharge obtained was only 0.3-0.4 cusec, in addition to the unwillingness of farmers to spend money on lining water courses to prevent seepage losses. It had been assumed that the cropping intensity before the investment was 70% with each acre yielding 3 quintals of wheat and 4.5 quintals of dry fodder and a net income of Rs. 50 per acre. After the investment, the cropping

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<sup>50</sup> See for example World Bank, *India - Gujarat Agricultural Credit Project*, p. 13.

<sup>51</sup> See for example World Bank, *India - Third Agricultural Refinance and Development Corporation Credit Project*, p. 32.

<sup>52</sup> Agricultural Refinance and Development Corporation, *Evaluation Study of Minor Irrigation Scheme- Installation of Shallow Tubewells in Karnal District*, Haryana (Bombay, 1977), pp. 1-12.

<sup>53</sup> Cusec is an acronym for Cubic feet per second, a standard measure of irrigation water flow rate in India.

intensity was expected to rise to 180% with a yield of 18 quintals each of wheat, paddy and fodder, yielding a net income of Rs. 1464 making for an incremental income of Rs. 1414 per acre. The study, like several others conducted by the ARC demonstrated that there had been both an underestimation of the baseline production and an overestimation of the post- tubewell production in drawing up the scheme. Yields did rise, from 6 to 10 quintals per acre in the case of wheat and from 7 to 13 quintals per acre in the case of paddy; this was far from the four fold increase expected. Cropping intensities before the investment, at 139% were already twice those assumed while planning the scheme; many borrowers had prior access to irrigation from wells, tubewells and canals. The cropping intensity after the investment did rise to 179%, practically achieving the target. Taken together, these statistics made for an incremental income of about Rs. 688 per acre; while this was enough for the farmer to pay off the loan and retain a handsome return, it was less than half the incremental income assumed while drawing up the scheme.<sup>54</sup>

Of the Karnal scheme's many shortfalls in meeting targets, perhaps the most interesting was in the incomplete transformation of the cropping pattern. It had been expected that high value wet crops such as wheat and paddy would entirely take over once assured irrigation was in place. However, farmers continued to grow low value dry crops such as maize, gram, millets and barley even as the area devoted to wheat increased from 32% to 40% that to rice from 12% to 30%;<sup>55</sup> Project planners had clearly overestimated the role of the profit motive as the sole driver of cultivator behavior.

### **Chasing Equity**

An interesting statistic that emerged from the Karnal study was that only two of the 118 beneficiary cultivators studied could be classified as small farmers. Equally interesting was the tendency of beneficiaries to increase the size of their holdings after the investment; the average holding increased by over a quarter from 10.43 acres to 13.25 acres with the trend particularly pronounced in the case of farmers who already had holdings larger than 20 acres (see Table 7.2).

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<sup>54</sup> ARDC, *Installation of Shallow Tubewells in Karnal District*, pp. 17-25.

<sup>55</sup> ARDC, *Installation of Shallow Tubewells in Karnal District*, p. 24.

Size of holdings (acres)	No of cultivators before investment	No of cultivators after investment
Less than 5	4	2
5-10	47	42
10-20	57	55
20 and above	10	19
Total	118	118

**Table 7.2: Impact of the Karnal tubewell finance scheme on landholding patterns**

**Source:** Agricultural Refinance and Development Corporation, *Evaluation Study of Minor Irrigation Scheme- Installation of Shallow Tubewells in Karnal District, Haryana* (Bombay, 1977), p. 31.

While the low coverage of small farmers was blamed by the Karnal study on the inadequate efforts of the state government,<sup>56</sup> the attention paid by the researchers to small farmers appears to have been more a function of concerns of the 1970s when the study was conducted, rather than one from the time of scheme sanction. In fact, the project had been sanctioned assuming a viable farm size nearly twice the threshold of landholding of farmers classified as small.<sup>57</sup> Domestically, the concern for small farmers was a function of an increasingly populist leftward turn by Indira Gandhi from 1969 onwards; this turn culminated in the 1971 election slogan *Garibi Hatao* (remove poverty), a brilliant response to the opposition's Indira *Hatao* (remove Indira). One of the many moves which affected agriculture in this context was the nationalization of the banks ostensibly to serve agriculture and the poor. An influential review of the credit system was also carried out (though this concentrated mostly on issues that had little to do with the ARC which was relatively new) which found that small farmers and the landless were hopelessly underserved by the system; even the formula used by the ARC to define small farmers owed its genesis to that review.<sup>58</sup>

<sup>56</sup> ARDC, *Installation of Shallow Tubewells in Karnal District*, p. 24.

<sup>57</sup> ARDC, *Installation of Shallow Tubewells in Karnal District*, p. 32.

<sup>58</sup> All India Rural Credit Review Committee, *Report of the All India Rural Credit Review Committee* (Bombay, 1969).

From about 1970 onwards, the ARC attempted to reorient itself to better serve small farmers; this coincided with the entry of the World Bank in agricultural lending. The Bank's annual reports on India's prospects, with the section on agriculture often written by consultants such as land reform expert Wolf Ladejinsky expressed great concern about the issue of equity. While the Karnal study made no comment on the trend of tubewell owners to increase land holdings, the Bank's reports had noted that the new agricultural strategy had exacerbated tenurial problems and rural inequality. With farming becoming increasingly profitable, land owners got rid of tenants and cultivated their land with wage labor. According to the Bank, small farmers and tenants could "be left to fend for themselves only at the price of overt discontent" which no longer lay "in the realm of theoretical assumptions of interested reformers".<sup>59</sup> The World Bank promoted concessions to small farmers through conditions on its credit to the ARC; at least 50% of the total credit was to be allocated to small farmers.<sup>60</sup> While these targets were met fairly easily in terms of the overall lending programme, it is unknown what proportion of minor-irrigation loans went to small cultivators.

The ARC and the banking system as a whole attempted to attract and service small farmers as part of their normal lending programmes. In keeping with the conditions of the "Treaty of Rome",<sup>61</sup> the agricultural finance sector had been instructed in 1967 to offer credit on the basis of the projected incremental income from the investment, rather than the capacity to pledge land for mortgage.<sup>62</sup> This was quite certainly not the case in the Karnal scheme, which required farmers to mortgage land; World Bank loan conditions continued to specify that incremental income be the basis for credit sanction well into the

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<sup>59</sup> World Bank, *India - Economic situation and prospects. South Asia series; no. SA 13* (Washington, DC, 1970), p. 40-41. Accessed online at <http://documents.worldbank.org/curated/en/1970/04/1555546/india-economic-situation-prospects> on 23rd February 2015.

<sup>60</sup> See World Bank, *India - Agricultural Refinance Corporation Credit Project* (Washington, DC 1975)

<sup>61</sup> Telegram from the US Embassy in Italy to the Department of State dated November 26, 1965. Accessed online at <https://history.state.gov/historicaldocuments/frus1964-68v25/d253> on 23rd February 2015.

<sup>62</sup> B. Sivaraman, "Scientific Agriculture is Neutral to Scale: The Fallacy and the Remedy" in Uma Kapil (ed.) *Indian Economy Since Independence* (1990), p. 125. This piece is a reprint of the Dr. Rajendra Prasad Memorial Lecture delivered at Kalyani University on 27<sup>th</sup> December 1972.

late 1970s, indicating that this condition continued to not be met.<sup>63</sup> At best, the inability to target small farmers was a result of the local cooperative land mortgage bank branch not having the technical personnel who could evaluate the projected incremental income. Together with World Bank conditions that credit only be extended to banks which had low overdues, this must have forced recourse to the traditional strategy of using the ability to pledge collateral as the criteria for sanctioning credit, thereby excluding the poor. At worst, the inability was a function of entrenched biases within the cooperative and rural banking system whose leadership was often close to the provincial large-landowning political class. The conditions that came with cheap World Bank money might be seen as a tool of the Central Government to circumvent provincial politics and direct the rural banking system to serve its own egalitarian goals.

The ARC made several concessions for lending to small farmers beginning from the end of the 1960s including lower down payments by cultivators, lower interest rates, longer loan tenures and providing refinance to the extent of 100% in the case of small farmer credit schemes.<sup>64</sup> The overall impact of the new small farmer bias is unknown; however, one independent study in Bihar in the early 1970s found that credit institutions were actively discriminating against farmers with holdings of less than 5 acres as they doubted their capacity to repay; high overdues would result in ARC credit to local banks being cut off. ARC schemes administered by cooperative banks, with their hierarchical and bureaucratic processes offered great obstacles to access for the poor and illiterate. Finally, while it was definitely the case that tubewell technology could not be scaled down beyond a point, local banks exacerbated the problem by committing to larger sized tubewells in their schemes even as smaller ones were available on the market. On the same lines, banks were strangely reluctant to finance bamboo tubewells, a local innovation which cost about

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<sup>63</sup> See World Bank, *India - Agricultural Refinance Corporation Credit Project* (Washington, DC, 1975), World Bank, *India - Second Agricultural Refinance and Development Corporation Credit Project* (Washington, DC, 1977) and World Bank, *India - Third Agricultural Refinance and Development Corporation Credit Project* (Washington, DC, 1979).

<sup>64</sup> ARC, *Reports 1969-74*.

a seventh as much as the smallest metal tubewell, even as they officially recognized the value of the innovation.<sup>65</sup>

The early 1970s saw the beginning of schemes specifically targeted at the poor as the administrators felt that rural social structures enabled larger farmers to pre-empt the services of non-targeted programmes.<sup>66</sup> These included the Small Farmers' Development Agencies (SFDA) and the Marginal Farmers and Agricultural Labourers (MFAL) programmes; both saw active participation of the ARC. Economic equity was not the only consideration; there was a growing realization that a productive leap could not come through increasing the yields of large farms alone. Crudely speaking, the SFDAs were targeted at smallholders who produced only a little for the market, but who could increase their yields with a small loan (often for a tubewell). MFAL was aimed at the landless and at holdings too small to be "viable" (or produce for the market); these loans were usually for subsidiary occupations such as poultry, dairying etc.<sup>67</sup> While not portrayed as such, this was no less than an attempt to remake the countryside by providing an exit route for the landless and for cultivators deemed too small for modern agriculture. The targeting of small loans at the poor, together with the doing away of the ability to offer collateral as a criteria for lending meant that such a programme would today be classified as microfinance.

Perhaps the inescapable root of the issue of inequality was the very solution that the World Bank advisors and the Indian bureaucratic elite had chosen to solve the scarcity-distribution problem of the Indian irrigation sector. The problem was seen as one of water provided by public systems being too little for high-yielding, intensive agriculture, and of the ability of the powerful to unfairly circumvent the regulatory distribution of public systems. Scarcity and corruption were to be banished by private investment in tubewells, though corruption had proven that public tubewells were not inherently unable to provide water in adequate quantities; it was just more public systems were needed, together with better enforcement of regulatory distribution. Once private tubewells were applied as a

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<sup>65</sup> E.J. Clay, *Innovation, inequality and rural planning: The economics of tubewell irrigation in the Kosi region, Bihar, India* (Unpublished Ph.D. dissertation, Sussex, 1974).

<sup>66</sup> Sivaraman, "Scientific Agriculture", p. 126.

<sup>67</sup> A note on the SFDA is available in World Bank, *India - Second Agricultural Refinance and Development Corporation Credit Project* (Washington, DC, 1977), p. 149-150.

solution, equity became a problem; the solution to the new problem was seen in widening the reach of credit to enable the smallest farmer to own a tubewell. To begin with, this approach neglected the fact that while the technology had shown a rapid propensity for downscaling, tubewells were simply not viable below a certain size of holding. For example, small farmers as defined in Karnal were those holding a maximum of 3.5 acres of dry land or 2 acres of irrigated land, but the viability of the scheme had been worked out on the assumption of a 7 acre holding.<sup>68</sup> Further, even a small tubewell for a holding deemed viable from the point of view of incremental income had much spare capacity as compared to a public tubewell which functioned annually for far longer hours; the proliferation of private tubewells represented much overinvestment, though this was often partly mitigated by water-sales to neighbors.

In contrast to the World Bank experts who saw privatization as the solution to the scarcity problem, a group of British development scholars focused on making public irrigation work for the poor. The Institute of Development Studies (IDS) at Sussex had been founded by Dudley Seers in 1966 and quickly established a radical reputation; in 1969 Seers attempted to turn the discipline on its head by attacking the “growth fetish” that had characterized it since its inception. In the 1970s, a group of researchers led by the biologist Robert Chambers founded something of a sub-discipline that would later be called irrigation sociology; this included Robert Wade who had produced one of the earliest studies of India’s Command Area Development Programme. Their initial focus was on canal irrigation and the general solution proposed by the IDS scholars was well characterized in the title of a paper by Wade on an innovative experiment in south India; *On substituting management for water*. South India’s canal systems were based on continuous flow, meaning all outlets in the system were open simultaneously; this was in contrast to the heavily managed systems of northwestern India based on rotational flow whereby each outlet got a pre-scheduled turn. Continuous flow was wasteful (as evaporation losses were constant) and inequitable as farmers in the head reach managed to appropriate more than their fair share. During a drought in 1976, rotational flow was adopted on a South Indian canal together with more equitable distribution, requiring the mobilization of the irrigation bureaucracy, local administration and the public. Broadly the programme was successful, with a more equitably distributed yield loss of only 25%,

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<sup>68</sup> ARDC, *Installation of Shallow Tubewells in Karnal District, Haryana*.

despite more than 50% shortfall in water supplies.<sup>69</sup> In general though, attempts to disseminate rotational water delivery to south India made little headway in the 1970s, though the progress was an improvement over the lip service of the previous decades. In the case of tubewells, the IDS scholars did much to propagate community-owned tubewells, but such programmes were miniscule in comparison to the boom in individual ownership.

Closely related to the targeting of small farmers were the ARC's attempts to target the "backward" eastern states; it set up a consultancy unit in the early 1970s to help banks and governments in these states to draw up groundwater irrigation schemes.<sup>70</sup> The eastern states of West Bengal, Bihar and Orissa were described in World Bank reports as "floating on water" as they contained a quarter of India's groundwater resources.<sup>71</sup> With barely 5% of the groundwater potential in this region developed by the mid-1970s (as compared to an all India average of 35% and 65% in the agriculturally advanced states), a great unrealized potential for enhanced food production was seen in this region. Optimistic as the Bank was, it was well aware that mere availability of plentiful groundwater supplies could not make for an agricultural revolution. The Eastern region was seen as being characterized by small and fragmented land holdings which could not justify individual groundwater investments; tenant farming also predominated in the region making for difficulties in providing security for loans. It was realized that some "group basis" would have to be evolved to organize groundwater development in the eastern states rather than the individual ownership and use which predominated in the boom states. However, public tubewells were notoriously inefficient and cooperative ownership came with the risk of domination by larger farmers. A final option would have been the installation of high capacity tubewells by large credit worthy farmers who would sell water to small farmers; this would risk exploitation of and discrimination against small farmers, besides unreliability.<sup>72</sup>

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<sup>69</sup> Robert Wade, "On Substituting Management for Water in Canal Irrigation: A South Indian Case", *Economic and Political Weekly* (1980) **15**:A147-A160

<sup>70</sup> ARC, *Report 1971-72*, p. 3.

<sup>71</sup> World Bank, *India- Economic situation and prospects* (Washington, DC 1975), p. 31.

<sup>72</sup> World Bank, *India- Economic situation and prospects* (Washington, DC 1975), p. 32.



Even as its consultants commented in its reports that individual ownership was inappropriate for the smallholder dominated eastern states, the Bank made only token gestures towards state and cooperatively-owned tubewells. In the West Bengal Agricultural Credit Project for example, the outlay was for 18,000 private tubewells and merely a hundred public tubewells despite explicit requests by the provincial government that the public tubewell component of the project be significantly expanded. The Bank cited the poor financial performance of public tubewells programmes which faced difficulties in collection of water charges with a consequent decline in the quality of services. While a further 200 tubewells were allocated to cooperative ownership as an experiment, the programme was never scaled up.<sup>73</sup> With the prejudice towards public ownership and the inability to develop cooperatives, the basis that groundwater development inevitably took in Eastern India was the one of water-sale by large farmers; a system whose potential to exploit small farmers by “replacing landlords with waterlords” was well known to the Bank.<sup>74</sup> By the early 1980s, ARC impact studies regularly used the terms “borrower beneficiaries” and “non-borrower beneficiaries” referring respectively to sellers and buyers of water. In a typical ARC tubewell scheme in Bihar, 75% of borrowers reported significant income from the sale of water; priced as it was at nearly 25 times the cost of electricity (which was the only marginal cost to the seller),<sup>75</sup> the business of selling water was extremely lucrative. By the 1990s, the equity impact of the development of “groundwater markets” would be a controversy amongst economists; opinion was split as to whether the markets were efficient and contributed to rural poverty alleviation or whether they were merely a source of accumulation and power.<sup>76</sup>

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<sup>73</sup> World Bank, *India - West Bengal Agricultural Development Project* (Washington, DC, 1975), p. 10. Accessed online at <http://documents.worldbank.org/curated/en/1975/04/725223/india-west-bengal-agricultural-development-project> on 23rd February 2015.

<sup>74</sup> World Bank, *India- Economic situation and prospects* (Washington, DC 1975), p. 32.

<sup>75</sup> Agricultural Refinance and Development Corporation, *Minor Irrigation in Bhojpur District, Bihar: An ex-post evaluation study* (Bombay, 1982).

<sup>76</sup> For the opposing viewpoints see Tushaar Shah, *Groundwater markets and irrigation development: Political economy and practical policy* (New Delhi, 1993) and S. Janakarajan, *Trading in Groundwater: A source of Accumulation and Power* (Chennai, 1995).

## Conclusion

Indian bureaucrats such as B. Sivaraman, saw irrigation at the centre of the new agricultural development strategy in the mid-1960s. The placement of the private profit at the centre of the drive for higher yields put private tubewells at the centre of irrigation policy; arguments about the inherent advantages of private ownership also proved useful in the quest for extending irrigation with limited state resources. In making a choice of the appropriate irrigation system, elite development actors explicitly apotheosized the role of the private profit motive in increasing production at the cost of the notion of social good.

Sivaraman pushed a programme of loan to cultivators to finance private tubewells from the cooperative banking system backed by the Agricultural Refinance Corporation. But lending to cultivators for the development of private groundwater irrigation facilities was not an automatic, demand driven choice for the Agricultural Refinance Corporation. The institution was initially averse to the idea, perhaps based on the traditional notion that the irrigation was the domain of the state, or at the very least of cooperatives, rather than of private initiative. Pressure from the government led the ARC to begin financing of private groundwater irrigation facilities in the late 1960s and groundwater quickly became its central business, demonstrating that groundwater development was where the largest demand for capital investment in Indian agriculture lay. From 1970 onwards, the programme was scaled up with massive loans from the World Bank which saw private irrigation and credit for the same as key bottleneck for improving agricultural production.

Internal studies of the ARC's early schemes highlighted a bias in lending in favour of large farmers which the Government of India and the World Bank were well aware of. While they tried to increase the flow of credit to small farmers for groundwater investments, their attempts met only with limited success. This was particularly true of eastern India, which had the most plentiful groundwater resources in the country but was dominated by small land holdings. While the World Bank realized that individual tubewell ownership and use was inappropriate for smallholder agriculture, it was biased against government and cooperatively-owned tubewells. The form of access to groundwater resources for small farmers which the ARC and the World Bank ended up promoting was one of purchase of water from larger farmers who owned tubewells; being fully aware of the potential exploitation of small farmers inherent in such a system.

## Conclusion

The case of wheat in India forms the central story in the historiography of the global Green Revolution. From the mid-1960s onwards, the production and yield of wheat increased at a rate faster than it had in the preceding period. This thesis argued that the increase in yields was driven by an expansion in the area of wheat irrigated; an expansion which took place largely due to an increase in the number of privately-owned tubewells. Not only did irrigation make for higher yields on its own but it also formed the basis for the use of other yield-enhancing inputs, most crucially fertilizers, which were normally only used in conjunction with irrigation. The dwarf or High Yielding Varieties (HYVs) had no role to play in the increased wheat yields though they were indeed in use in India during the boom. As this thesis showed, the advantages of HYVs over tall varieties developed in India were far from certain. HYVs did produce higher yields at extremely high fertilizer doses but tall Indian varieties performed better at moderate doses. There is no evidence that any substantial section of Indian wheat cultivators applied a high-enough fertilizer dosage to be at the threshold where they might benefit from switching varieties; there is in fact much evidence to the contrary. At any dosage, the dwarf varieties made for inefficient use of fertilizer which was a very expensive and scarce input; a cheaper “revolution” could well have been orchestrated by spreading available fertilizer thin on tall Indian varieties rather than concentrate high doses on a few fields growing HYVs. Thus not only were dwarf varieties not necessary to increase wheat production; their adoption very likely made for a more inefficient agriculture.

The standard stories of the Green Revolution imply that the state neglected agriculture in favour of industry during the Nehruvian period; this resulted in indifferent production. Food production was rescued from this stasis when Indian agriculture embraced science, particularly the HYVs, resulting in spectacular strides in the production and yield of foodgrains in India during the Green Revolution of the 1960s and 1970s. By examining the statistics, this thesis showed that the Nehruvian period saw a substantial growth in not just the production but also the yield of foodgrains in India. The performance of food production during this period was in fact better than during the late 1960s and early 1970s, which is implicitly assumed to be a period of high growth in studies focussed on the Green Revolution. I thus argue that a period of high growth in production and yield began more or less at the end of the colonial period rather than the mid-1960s as is usually implied. A very specific story of wheat which does fit in to the standard production narrative in

seeing something of a revolution in the late 1960s and 1970s has typically been taken to represent Indian food production and even Indian agriculture as a whole, though it was a relatively minor part of India's food basket. And as argued earlier, the newly-developed HYVs had little to do with the boom in wheat yields which were driven largely by irrigation.

Having challenged our productionist and innovation-centric picture of the Green Revolution, this thesis sought to reconceptualise our understanding of the period with it focus on irrigation. It showed that there was a shift in emphasis from public irrigation facilities to *privately*-owned tubewells in the mid-1960s; the latter largely accounted for the rapid rise in wheat irrigation. The strategy of publicly-owned irrigation systems which had formed the thrust of India's irrigation efforts was to spread water thin over a large area; this not only served the objective of social equity by benefiting a large number of farmers but also made optimal use of scarce water to maximize *total* production. However, in the mid-1960s, the idea of the rational peasant took hold and his profit-maximization objective was put at the centre of the drive for higher production. Intensive use of water and its timely application were seen as the key to higher yields and profits. Public irrigation systems were seen as unable to enable the intensive water use the cultivator demanded; there was a conflict between the objectives of private profit and of social equity. The World Bank hence recommended that the way forward for irrigation development was a greater reliance on *private* tubewells which would enable a plentiful, unrestricted supply of water to the cultivator at will; independence from the regulatory rationing of water inherent to public systems was also seen as the key to promote the use of new risky inputs such as chemical fertilizers. Aided by the World Bank, and through a public company called the Agricultural Refinance Corporation, the Indian government began to extend cheap loans to cultivators for groundwater irrigation in the late 1960s, precipitating a tubewell boom. It was well known that even with loans not all cultivators could afford tubewells; thus the sacrifice of equity objectives was a conscious choice of elite development actors during the Green Revolution. Their attempts to mitigate rising inequality by targeting loans at the poor met with only limited success in large part due to the bias in favour of individual, rather than community ownership.

This thesis argued that the idea of the rational self-interested farmer was central not just to the reform of irrigation; it formed the general thrust of the New Agricultural Strategy which is credited with heralding the Green Revolution. The mid-1960s saw a shift in the

intellectual landscape of development studies. On the one hand, there was the well-known shift in emphasis from industry to agriculture which was seen as capable of being an engine of economic development. But this showed that there was also a lesser known shift, one in the idea of how agriculture might be developed. Its genesis lay in the theory of the “poor but rational” Third-World peasant most clearly articulated by the Chicago economist Theodore Schultz. The peasant’s rationality implied that Third-World agriculture was amenable to standard economic theory and that the peasant would respond to price incentives to increase production; his continued poverty despite being rational implied that he had already optimised the use of traditional inputs and any further productivity gains could only come from new inputs grounded in scientific research. I argued that this theory was central to advice the World Bank gave to India in 1965 which became the basis of India’s New Agricultural Strategy. This theory was applied to decisions beyond irrigation; most obviously in the case of incentive prices. Reliance on the profit motive of a limited number of “progressive farmers” to drive production was also central to the choice of the HYV wheat seeds; the objective was to induce a few farmers to use very high and perhaps inappropriate fertilizer doses in the quest for super normal yields and thus shake up traditional wheat cultivation.

Thus this thesis argued that the defining feature of India’s agricultural policy in the period since the mid-1960s was that the profit motive became more central to agricultural policy than it had before; this was despite an acute awareness that such a policy risked rising inequality. In doing so, it emphasizes the issues of unequal access to resources that underpinned policy and the consequent rising inequality, both central to critiques of the Green Revolution but only mentioned in passing in the historiography which puts scientific research and innovation at the centre of our picture of the Green Revolution. It thus underlines the fact that inequality was not an odd side-effect of the Green Revolution; it was built in to both economic policy and technology choice. This thesis thus argued for the need to look beyond technology alone to the larger shift in the political economy of Indian agriculture. As the economist CH Hanumatha Rao argued in the early 1970s, the use of High Yielding Varieties of seeds together the concept of “productive irrigation” merely served to justify the appropriation of fertilizer and water resources in an economically inoptimal manner by a few farmers who were already resource rich.<sup>724</sup> In

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<sup>724</sup> C. H. Hanumantha Rao, "Socio-Political Factors and Agricultural Policies", *Economic and Political Weekly* (1974) 9: 1285-1292. A similar point was later made at

other words a certain type of economics much more important than a certain type of science.

But while it points to the centrality of the idea that the private profit motive would lead to higher production in policymaking, this thesis also argues that the state played the central role in the Green Revolution; and this role was not confined merely to the research carried out in the public sector. Incentive prices meant to enthuse the profit-hungry farmer not only helped orchestrate a shift to wheat cultivation in the richest irrigated lands of the Punjab, but also spurred the expansion of irrigation with private tubewells. In fact this thesis argued that that attainment of notional food self-sufficiency in India had as much to do with procurement and distribution as it had to do with production alone. The state took to heavy intervention in the foodgrain market with the setting up of the Food Corporation of India (FCI) which procured food from the surplus districts for subsidized distribution in the cities and deficit areas. The FCI also built up a stock of foodgrains to tide over years of low production; it was these cyclical crises rather than merely low production that perhaps constituted India's real food production problems. The role of procurement in managing India's food economy was particularly important in the case of rice which saw no sharp rise in productivity during the Green Revolution years. Installed to irrigate wheat, Punjab's tubewells were used to cultivate rice during the monsoon; the crop had little local demand and the region, which had no history of rice cultivation quickly became the leading supplier of rice to the FCI. The massive investment in rural electrification, together with subsidies and the provision of cheap credit which fuelled the tubewell boom also point to the crucial role of the state in enabling the use of the central technology of the Green Revolution. Indeed, the limited capacity of the state to engage with the financial and logistical challenges of intensive rural action may well explain a policy focussed on a few large or "progressive farmers" in a small region already advanced in state facilities cultivating a relatively minor crop.

In shifting the focus away from the story of the miracle seeds and fertilizers alone and in pointing to the role of tubewells, this thesis has made important additions and corrections to the historiography of the Green Revolution. To begin with, it has underlined the crucial role played by advice and support from the World Bank in the evolution of India's

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length by Ashok Rudra, "Technological Choice in Agriculture in India over the Past Three Decades.", in F. Stewart (ed.), *Macropolicies for Appropriate Technology in Developing Countries*, (Boulder, CO, 1987), pp. 22-73.

agricultural strategy; thus expanding our picture of the role of external agencies in the Green Revolution beyond the Rockefeller Foundation, which has typically been the centre of attention. In doing so, it has pointed to the important role played by economists and economic argument in the Green Revolution; a role which has been inadequately examined in the historiography.

Largely by omission, the historiography has implicitly characterized irrigation as a colonial-era technology seemingly outstripped in importance by the input of “science” with the coming of the miracle wheat seeds; this thesis has argued that irrigation was in fact the real driver of yields in the so-called Green Revolution. The emphasis on the role of private tubewells in increased productivity provides a powerful corrective to the focus on plant breeding in our accounts of twentieth-century agricultural development, and in doing so, it critiques the uncritical acceptance by innovation-obsessed historians of the early claims of the Rockefeller Foundation, which was quick to attribute India’s spectacular performance in increasing its wheat production exclusively to the dwarf wheat varieties it had developed. By arguing for the centrality of an old input (irrigation) in driving what is usually characterized as a “modern”, research and innovation-driven revolution, this thesis has not only challenged the specific accounts of the wellsprings of Green-Revolution productivity growth but also sought to provide a more general critique of innovation-centric accounts of science and technology histories. It has argued for paying attention not just to innovation or first use of a technology but also to *use* more generally. It has showed that such a refocussing can contribute to a better understanding of the changing relative importance of old and new technologies through time, as well as answer historical questions beyond the question of technology alone.

This thesis argued that the novel miracle seeds just happened to come into use at a time of incentive prices, a liberal fertilizer policy and above all, an expansion in the area of wheat irrigated were contributing to increased wheat production. On the same lines, it has been careful not to characterize the private tubewell as some kind of definitive technological breakthrough in the history of irrigation. I argued that while privately-owned tubewells did indeed have some advantages over public irrigation facilities, most of the increase in yields took place due to the general expansion in irrigation facilitated by the private-tubewell boom rather than any specific technological advantages of private tubewells. Private tubewells showed only a marginal advantage over the well-managed canal systems of northwestern India, the region which was the centre of the wheat

revolution; it was thus unfair to characterize canals as entirely unsuited to modern agriculture. While there was a high correlation between the ownership of a tubewell and the intensive use of fertilizers, this was more due to the generally larger resources possessed by tubewell owners and less due to any inherent advantages of private tubewells. This thesis thus argued that the private tubewell irrigation boom in wheat was the result of conscious policy choices rather than technological superiority; as the irrigation engineer Nawab Ali Nawaz Jung Bahadur argued during the late colonial period, only under special conditions of “crops, climates and markets” could groundwater irrigation be viable on a large scale. The perceived advantages of tubewell irrigation varied through the twentieth century; they were seen primarily as a means of extending irrigation in areas uncommanded by canals and for quick extension of irrigation in times of crises. Only in the 1960s did the idea of tubewell irrigation as a *better* means of irrigation take hold. This adds to my argument about paying greater attention to technologies in use to better understand both the changing meaning of technology and of the wider social questions they reflect.

This thesis thus tells the neglected history of irrigation in twentieth-century India with a particular focus on the tubewell beyond just the Green Revolution period when the technology became very important. It showed that irrigation was seen as the most important means of agricultural improvement as it enhanced yields, promoted multiple cropping and incentivized the use of other inputs such as improved seeds, fertilizers and generally improved cultivation by mitigating risk; this perceived importance resulted in substantial investment in irrigation technologies of all kinds throughout the period. While both canal and groundwater irrigation have expanded substantially during the period, the latter has gained in relative importance during the twentieth century. The policy emphasis on the mode of irrigation was shaped by a conflict between the utility of large and small-scale technology, between public and private ownership and between agriculture and industrial investment; these conflicts came to a head during the wartime food crisis and the drought and economic crisis of the mid-1960s both of which saw an emphasis on tubewells rather than large surface irrigation schemes as the key to quick results. While the wartime crisis put the public tubewell on the central government’s agenda, the 1960s saw an explicit valorisation of the private tubewell resulting in its quick rise to the most important contributor of irrigation in India even as canal irrigation continued to grow slowly through the period.



I began by showing that wells were an important source of irrigation in turn of the century India and that they had received significant albeit sporadic state support in some Indian provinces. The Indian Irrigation Commission (1901-03) placed an emphasis on private wells rather than large expensive surface irrigation projects as the means to extend irrigation. In the next three decades, provincial governments led by UP supported and incentivized private investment in new motorized groundwater extraction technologies such as tubewells. Under the leadership of Sir William Stampe during the interwar years, the UP Irrigation Branch embarked upon the first rural-electrification programme in India, using small canal-falls power plants to energize a network of state-owned tubewells, pioneering the large-scale use of tubewells in India and indeed the world. During the Second World War, Stampe was appointed the Irrigation Adviser to the Government of India and he pushed tubewells as a solution to India's immediate and long-term food problem; this put tubewells on the central government agenda and his plans would be executed by postcolonial India. These developments demonstrate that the interest of the colonial state extended beyond large-scale technologies such as canals to embrace a variety of small-scale groundwater irrigation systems such as the tubewell. Thus tubewells progressively emerged as an important technology at the local, regional and national level during the last half century of colonial rule; tubewell schemes were an early exemplar of global postwar development.

In the historiography of technology in India, the interwar period has implicitly been seen as something of an interregnum with little material development as the focus has been on discursive analysis around the theme of science, technology, development and nationalism. By showing that the use of the central technology of the postcolonial Green Revolution was pioneered during this period, this thesis argued for the importance of focussing on material developments in this period as well. Similarly, this thesis illustrated that an examination of developments during the interwar, wartime and immediate-postwar colonial years can show that independent India's heavy commitment to big dams was not merely a result of the fetishization of the TVA model but was led by the concerns of irrigation. It showed that irrigation engineers in India had long proposed dams for irrigation, seeing them as the logical conclusion of India's long engagement with water management. While the prohibitive cost meant that few were built during the colonial era, this changed with the reduced fiscal conservatism of the postwar developmental state

and a perceived exhaustion of opportunities for conventional canal schemes leading to a push towards storage (dam) based schemes.

The utility of such an approach however extends beyond the specific *telos* of Nehru's dams or events such as the Green Revolution. This thesis argued that expanding our focus beyond general nationalist pronouncements on technology to include the activities of actors within an increasingly heterogeneous colonial state can shed light on questions beyond a general linking of technology with nationalism to questions such as technology for what, for whom and of what kind. Thus it showed that while both Sir William and nationalist technocrats such as Meghnad Saha were enthusiasts for electrification, Sir William's was a vision which embraced a small-scale, rural-agricultural modernity which was in stark contrast to the large-scale, urban-industrial vision of nationalist technocrats.

The historiography has characterized the Nehruvian period as one which saw a neglect of agriculture. This reading is based on the low *relative* share of public resources devoted to agriculture which changed in the mid-1960s, as well as an uncritical acceptance of the arguments of those who called for specific changes in agricultural policy. This thesis used the case of irrigation to argue that the Nehruvian period in fact saw a significant investment in agriculture; the period saw a massive scaling up of colonial-era commitment to public irrigation systems even as the relative share of public money allocated to agriculture may have been higher in later periods. This investment during the Nehruvian period took place as a result of provincial pressures and commitments made during the last years of colonialism; influential central government technocratic bodies such as the Planning Commission were sceptical of investment in irrigation, particularly in the case of very large projects. The big dam was less central to water resources development during the Nehruvian era than is usually assumed; public tubewells were an integral part of irrigation investment during the period which saw some of the largest programmes of tubewell construction in the world. So great was this scaling up of colonial-era irrigation investment of all sorts that resources were stretched thin and projects progressed very slowly; this made for considerable disillusionment with public irrigation systems by the mid-1960s. The mid-1960s also saw a period of severe drought, which together with a crisis of public finances contributed as much as shifting ideology in putting the *private* tubewell at the centre of efforts to increase irrigation.

This thesis was ultimately about colonial and postcolonial economic development. It showed that there was considerable continuity in development praxis through the end of colonialism and the early postcolonial period. This praxis was shaped by ideas and debates, but also by past commitments and responses to crises. Changes in ideas as well as praxis was a slow and negotiated process with the two often seemingly unlinked. Thus for example while the state gradually loosened its purse strings on an ad-hoc basis when it came to irrigation investment from the end of the Second World War, there continued to be considerable scepticism among the central technocratic bodies such as the Planning Commission which played the role of the fiscal conservative attempting to keep irrigation investment in check, just as the India Office in London had during the Raj. Officially replacing the revenue-centric development philosophy of the colonial era with a criteria some felt was more suited to the planned economy of the welfare state was thus a long and contested process. While the Irrigation Commission had favoured a policy centred on private wells in the early twentieth century, the public irrigation systems favoured by the well-entrenched irrigation bureaucracy continued to form the rhetorical emphasis of irrigation development well into the postcolonial period even as state support for private irrigation investment continued to grow slowly; it was only in the mid-1960s that the emphasis of state efforts shifted decisively in favour of private tubewells.

Despite considerable disappointment, agricultural development as reflected in food production saw much success in postcolonial India. Spectacular successes reflecting a breakthrough were few and far in between and of a minor and circumscribed nature like the case of wheat in northwestern India. At the macroscale, this success was only discernible the form of a slow and unsteady (but faster-than-before) growth in production and yields over a few decades, rather than a sharp increase in a short well-defined period. The lack of a sharp overall increase had to do not with lack of technology but with limited capacity of the rural state; this was reflected in the slow execution of the last-mile infrastructure of irrigation projects, meeting the logistical challenges of delivering inputs and developing markets, credit delivery and limitations of extension services.

The importance of services such as extension over research has been noted by others such as Jonathan Harwood. While Harwood argues that an understanding of the turn of the century central European “Green Revolution” in developing peasant agriculture can aid

in the work of Third-World development practitioners today,<sup>725</sup> this thesis has argued that our understanding of the classic case of the Indian Green Revolution itself is severely flawed. To the extent that the term itself has any purchase beyond its use by historical actors, we need to reconceptualise it as a slow process of postwar agricultural development rather than a sudden break suggested by the seductive term. This requires a clearer understanding of postcolonial agricultural development before the arrival of the HYV seeds, an extension of our focus to technologies and inputs other than improved seeds, and indeed to extend our focus beyond technology alone.

Thus the first direction in which the insights of this thesis may be extended is in developing a more detailed understanding of technical and economic changes in Indian agriculture during the Nehruvian period to understand how the break from the colonial period took place, and what effect this break had on the countryside. In particular, while this thesis has engaged more substantially with the important case of rice than other histories of the Green Revolution in India, an even clearer understanding of the impressive productivity growth in India's most important food crop in the 1950s is called for.

This thesis may also be extended in other directions. It contains but an outline of the rich history of groundwater irrigation in India, focussing on one mode (the tubewell) and crop (wheat) which was most prevalent in the alluvial river basins of northwestern India. Besides extending a focus to other regions (for example Gujarat, West Bengal and Tamil Nadu), other technologies (such as pumpsets, borewells and dug-cum-borewells) and crops, there is much scope for a larger contribution to the history of science and the environment. One may tell the story of the development of groundwater science and geohydrology in India or of how actors engaged with the concepts of risk and sustainability in groundwater development. An initial survey reveals that the Geological Survey of India (GSI) took increasing interest in questions of water supply in the twentieth century, initially for industrial and military installations and then for irrigation; it advised on the question of a safe limit of pumping for the Ganges tubewell project in the 1930s. Its groundwater-related activities greatly expanded during the war due and culminated in the setting up of an Engineering Geology and Groundwater Section after

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<sup>725</sup> Jonathan Harwood, *Europe's Green Revolution and Others Since: The Rise and Fall of Peasant-friendly Plant Breeding* (London, 2012), p.173.

the war. The question of mapping India's groundwater resources was considered crucial; an American aided All India Groundwater Exploration Programme in the 1950s was the largest such effort in the world. Yet, even as geologists and the new discipline of geophysicists adopted sophisticated instrumentation and methods of analysis, both the colonial and Nehruvian state employed traditional water diviners at the highest levels and there was considerable scientific and political debate about the efficacy of divining and scientific geology. An exploration of these issues can on the one hand extend the history of the GSI, as well as how the state engaged with and used science and rationality.

The scaling up of groundwater irrigation efforts in the 1960s was accompanied with rising concern about determining the safe long-term limits of pumping and regulating groundwater development. These concerns came from banking institutions led by the World Bank concerned about the return from their investments; conditions limiting the density of tubewells as well as funds for developing provincial groundwater investigation bodies were an important part of its loans to the ARC. An explorations of these concerns of sustainability and the production of scientific knowledge to serve the banking industry can add much to our understanding of the history of the World Bank as well as of the environmental history of the Green Revolution.

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